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Thiokol Corporation

Flight Motor Set 360H005 (STS-28R) Final Report

Volume V
(Nozzle Component)

September 1990

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Thiokol CORPORATION

SPACE OPERATIONS

P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

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Prepared by:

DAN SMITH, JR. / Russell J. George

D. M. Smith, Jr.
Nozzle/TVC Design

Approved by:

R. K. Wilks, Manager
Nonmetallic Component Design

J. E. Fonnesbeck, Supervisor
Nozzle/TVC Design

H. D. Huppi
Systems Integration Engineering

E. L. Diehl
SRM Nozzle Programs

System Safety

Certification Planning

Data Management 9-18-90

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1.0 INTRODUCTION

A review of the performance and postflight condition of the STS-28 Redesigned Solid Rocket Motor (RSRM) nozzles is presented in this document. Applicable Discrepancy Reports (DRs) and Process Departures (PDs) are presented in Section 5.0. The Nozzle Component Program Team (NCPT) performance evaluation and the Redesign Program Review Board (RPRB) assessment is included in Section 6.0.

The STS-28 nozzle assemblies were flown on the RSRM Fifth Flight (Space Shuttle Columbia) on 08 August 1989. The nozzles were a partially submerged convergent/divergent movable design with an aft pivot point flexible bearing. The nozzle assemblies (see Figure 1) incorporated the following features:

a. RSRM forward exit cone with snubber assembly

b. RSRM fixed housing

c. Structural backup Outer Boot Ring (OBR)

d. RSRM cowl ring

e. RSRM nose inlet assembly

f. RSRM throat assembly

g. RSRM forward nose and aft inlet ring

h. RSRM aft exit cone assembly with Linear-Shaped Charge (LSC)

i. RTV backfill in Joints 1, 3, and 4

j. Use of EA913 NA adhesive in place of EA913 adhesive

k. Redesigned nozzle plug

l. Carbon Cloth Phenolic (CCP) with 750 ppm sodium content

Figures 2 and 3 show the CCP material usage for the STS-28 forward nozzle and aft exit cone assemblies.

2.0 OBJECTIVES

The RSRM Fifth Flight test objectives, as outlined in TWR-17544, Vol. I Flight Motor Set 360H005 Final Report/System Overview, are as follows (CPW1-3600 paragraph numbers are in parentheses):

Objectives by Inspection:

G. Verify that flexible bearing seals operate within the specified temperature range (3.2.1.2.3.b).

H. Verify that flexible bearing maintained a positive gas seal between its internal components (3.2.1.2.3d).

L. Inspect flexible bearing for damage due to water impact (3.2.1.4.6).

N. Verify performance of the nozzle liner (3.2.1.4.13).

X. Verify that nozzle metal parts are reusable (3.2.1.9.b).

Y. Verify through flight demonstration and a postflight inspection that the flexible bearing is reusable (3.2.1.9.c).

AJ. Verify by inspection the remaining nozzle ablative thicknesses (3.3.6.1.2.7).

AK. Verify the nozzle performance margins of safety (3.3.6.1.2.8).

3.0 SUMMARY/CONCLUSIONS

Compliance to the flight test objectives is discussed below.

G. Both flex bearing seals operated as expected within the specified temperature range.

H. Inspection of the flex bearings showed a positive gas seal was maintained between the internal components.

L. There were no indications of damage to the flex bearings due to water impact.

N. No nozzle flame front liner erosion pockets were noted. All wedgeouts observed occurred postburn and do not affect liner performance. No prefire anomalies were found.

X. All metal parts which have gone through refurbishment are acceptable for reuse. All other metal parts are in the refurbishment cycle. None have been rejected to date.

Y. Both flex bearings performed satisfactorily during flight. A visual postflight inspection showed no evidence of anomalies. The STS-28A (LH) flex bearing passed acceptance tests (TWR-60080) and can be reused. The STS-28B (RH) flex bearing was written up on DR 165119 for unacceptable unbond area. This flex bearing has not undergone acceptance tests as yet.

AJ. All nozzle liner remaining ablative thicknesses have met the design safety factors.

AK. All nozzle liner performance margins of safety were zero or greater.

4.0 RESULTS/DISCUSSION

All STS-28 postflight nozzle observations are discussed in detail below. CCP liner Performance Margins of Safety (PMS) are presented using measured erosion, and corresponding measured char values adjusted to the end of action time.

4.1 STS-28A (LH) Nozzle/Flex Bearing

Overall erosion of the STS-28A forward nozzle assembly CCP ablative liner was smooth and uniform. All CCP delaminations, wedgeouts, and pop-ups were determined to be postburn occurrences. Soot was observed in joint 2 up to the primary O-ring, but there was no blowby, erosion, or heat effect to the primary O-rings.

Postflight subassembly flow surface gaps are shown in Figure 4. Overall views of the nozzle are shown in Figures 5 through 7.

4.1.1 STS-28A Nozzle Components

STS-28A Aft Exit Cone Assembly

Overall views of the STS-28A aft exit cone fragment are shown in Figure 7.

The aft exit cone was severed aft of the compliance ring by the LSC. The nozzle severance system performance was nominal. The exit cone cut was clean, with no unusual tearing or breaking. The remaining aft exit cone fragment showed missing CCP liner 360 degrees circumferentially. This is a typical postflight observation and occurs at LSC firing and at splashdown. Glass Cloth Phenolic (GCP) plies exposed by the missing liner showed no signs of heat effect. A void in exposed EA946 adhesive was found at approximately 80 degrees and measured 3 inches axially by 1 inch circumferentially. There was no metal exposed at this location.

A small pin-hole, approximately 0.010 inch in diameter, was found in the polysulfide at 268 degrees. This was 0.10 inch inboard of the aft exit cone shell. A small fiber, believed to be GCP, was embedded in the pin-hole. A foreign residue was also found on the surface of the polysulfide from 265 to 271 degrees. The residue was determined to be silica and silicon with small traces of salt.

The polysulfide groove fill on the forward end of the aft exit cone showed no separations. Postflight measurements of the polysulfide groove radial width (Table 1) show that the GCP insulator did not pull away from the aluminum shell during cooldown. The polysulfide shrank axially aft up to 0.08 inch.

There were postburn separations observed within the GCP measuring 0.020 inch radially and were noted on the Outer Diameter (OD) of the primary O-ring groove from 135 to 150 degrees.

STS-28A Forward Exit Cone Assembly

The forward exit cone showed missing CCP liner over the center-to-aft portion of the cone 360 degrees circumferentially. This is a typical postflight observation and occurs at splashdown and during Diver Operated Plug (DOP) insertion. The GCP insulator exposed by the missing liner showed no signs of heat effect. The CCP liner remained bonded on the forward 12 inches, 360 degrees circumferentially, and on the aft 3-to-7 inches of the cone from 180 to 210 degrees. These portions showed nominal erosion with no major washing or pocketing. The aft 3-to-7 inches of intact liner at 180-to-210 degrees showed the typical dimpled erosion pattern that has occurred on all flight and static test forward exit cones. The maximum radial depth of the dimpled erosion was 0.10 inch.

The aft end of the forward exit cone showed no bondline separations. The forward end of the forward exit cone showed bondline separations between the EA946 adhesive and the metal housing 360 degrees (with a maximum radial width of the separation 0.040 inch), cohesive separations within the adhesive (0.020 inch maximum radial width) from 135-to-150 degrees, and glass-to-glass separations from 0-to-5 degrees (0.015 inch maximum radial width), and 340-to-345 degrees (0.010 inch maximum radial width). Figure 8 lists the location and radial width measurements of all separations on the forward exit cone. These separations are typical observations which have been seen on previous static test and flight nozzles, and have been shown to occur postburn.

Photographs of the sectioned forward exit cone liner are presented in Figures 9 through 12. Char and erosion analysis of the sections is presented in Table 2. Figure 13 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.21 occurring at station 8 (180 degrees).

STS-28 Throat Assembly

The post-fired mean diameter of the throat was 55.975 inches (erosion rate of 8.78 mils/second based on an action time of 120.5 seconds). RSRM Nozzle postburn throat diameters have ranged from 55.787 to 56.048 inches. The flow surface bondline gap between the throat and throat inlet rings was 0.15 inch and is typical of past static test and flight nozzles.

Erosion of the throat and throat inlet rings was smooth and uniform with no wedgeouts observed. Popped-up charred CCP material was observed on the forward 1.5 inches of the throat and throat inlet ring intermittently around the circumference on the forward ends of both rings. Sharp edges indicate the popped-up material occurred after motor operation.

Bondline separations between the EA913 NA adhesive and the steel throat support housing were observed on the aft end 360 degrees circumferentially. The maximum radial width of these separations was 0.040 inch. Metal-to-adhesive bondline separations measuring 0.01-to-0.03 inch wide radially were observed on the forward end of the throat assembly circumferentially except at 75-to-105, 165-to-180, and 270-to-330 degrees. Figure 14 lists the location and radial width measurements of all separations on the throat assembly. These separations are typical observations which have been seen on previous static test and flight nozzles and have been shown to occur postburn.

Photographs of the sectioned throat assembly liner are presented in Figures 15 through 18. Char and erosion analysis of the sections is presented in Table 3. Figure 19 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.03 occurring at station 8 (90 degrees).

STS-28A Nose Inlet Assembly

The ply angle of the forward nose (-503) ring was checked and found to be of the RSRM design. The flow surface bondline gap between the -503 ring and the aft inlet (-504) ring was 0.20 inch. The flow surface bondline gap between the -503 ring and the nose cap was 0.05 inch. These post-fired measurements are typical of past static test and flight nozzles.

The forward nose (-503) and aft inlet (-504) rings showed smooth erosion with no pockets or wash areas observed. One postburn wedgeout was found on the forward 1.1 inches of the -504 ring at 40 degrees and measured 13.5 inches circumferentially by 0.45 inch radially. Popped-up charred CCP was also noted on the forward 1.2 inches at 15 degrees. Slag deposits were noted on the -503 ring. Impact marks, possibly due to loose debris, were located at 0, 185, and 245 degrees. The mark at 245 degrees was covered with slag.

The nose cap exhibited typical minor wash areas on the forward 24 inches (0.15 inch maximum radial depth). The aft 2-to-3 inches showed intermittent popped-up charred CCP material and typical postburn wedgeouts at 0-to-84, 110-to-248, 275-to-306, and 336-to-0 degrees from typical postburn wedgeouts. The maximum radial depth was 0.65 inch at the cowl interface. Sharp edges indicate the popped-up material and the wedgeouts occurred after motor operation. No wedgeouts were observed on the forward end of the nose cap.

The aft end of the nose inlet assembly (-504 ring aft end) showed metal to adhesive bondline separations (0.01 inch maximum radial width) occurring intermittently around the circumference. Figure 20 lists the location and radial width measurements of all separations on the nose inlet assembly. These separations are typical observations seen on previous static test and flight nozzles and have been shown to occur postburn. No separations occurred at the aft end of the nose cap.

Photographs of the sectioned nose inlet assembly rings are presented in Figures 21 through 28. Char and erosion analysis of the sections is presented in Tables 4 and 5. All margins of safety were positive, with a minimum of 0.15 occurring at station 32 (270 degrees) for the -503/-504 rings, and 0.03 occurring at station 24 (90 degrees) for the nose cap. Figure 29 shows the nose inlet assembly erosion measurement stations.

STS-28A Cowl Ring

Closeup views are shown in Figures 30 through 33. All cowl vent holes appeared plugged with soot and slag on the OD of the ring except at 80, 90, 130, 180, 190, 200, 290, and 310 degrees. These remained partially open.

Typical ridged erosion was observed intermittently around the cowl circumference. The forward portion of the ring eroded a maximum of 0.15

inch greater than on the aft portion of the ring. This is a result of the low ply angle of the cowl ring and has been observed on the majority of flight and static test nozzles. Postburn wedgeouts and popped-up CCP were observed on the aft 3-to-4 inches intermittently around the circumference.

There were no bondline separations on the forward end of the cowl ring.

Photographs of the sectioned cowl ring are presented in Figures 34 through 37.

Char and erosion analysis of the sections is presented in Table 6 (Stations 0 through 7). Figure 38 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.25 occurring at station 2 (0 degrees).

STS-28A Outer Boot Ring/Flex Boot

Closeup views are shown in Figures 30 through 33.

The bondline between the OBR and cowl ring remained intact with no indications of flow. The flow surface bondline gap was 0.20 inch and is typical of past static test and flight nozzles.

The structural backup OBR was intact. The flow surfaces showed smooth erosion with no pockets or wedgeouts. Intermittently, minor wash areas extended from the cowl to the forward 1 inch of the OBR. Postburn, popped-up charred CCP was found on the forward 2 inches intermittently. The OBR aft end showed typical delaminations along the charred CCP plies. The aft tip adjacent to the flex boot was fractured and wedged out intermittently around the circumference. Sharp edges on the surfaces indicate this occurred after motor operation.

Photographs of the sectioned OBR are presented in Figures 39 through 42. Char and erosion analysis of the sections is presented in Table 6 (Stations 8 through 12). All margins of safety were positive, with a minimum of 0.48 occurring at station 11.3 (45 degrees).

The flex boot remained attached to the outer boot ring 360 degrees circumferentially. The cavity side of the flex boot was evenly sooted and showed no evidence of flow or erosion (Figures 43 through 45). It appeared typical of previous flight and static test motor flex boots. A minimum of 3.25 NBR plies remained around the circumference after motor burn. Table 7 presents the flex boot material affected depths and Performance Margins of Safety (PMS). The worst-case PMS was 0.26 at 270 and 315 degrees.

STS-28A Fixed Housing

The fixed housing insulation erosion was smooth and uniform (see Figures 5 and 6). Postburn wedgeouts of charred CCP material were observed on the forward 2 inches intermittently around the circumference. The maximum radial depth of these wedgeouts was 0.5 inch. There was no heat effect to the GCP.

Separations were observed on the aft end of the fixed housing between the metal and EA913 NA adhesive at 227 degrees, between the adhesive and GCP at 235 degrees, and within the adhesive at 110 and 230 degrees. All separations measured 0.005 inch radially.

The fixed housing aft flange showed no damage to the metal surfaces, bolt holes, or O-ring grooves. No corrosion of the flange surface was observed, except for minor surface rust on the alignment pin. A residue of white Teflon tape adhesive was found on the steel flange next to the EA913 NA bondline.

Photographs of the sectioned fixed housing assembly liner are presented in Figures 46 through 49. Char and erosion analyses of the sections are presented in Table 8. Figure 50 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.52 occurring at station 3 (90 degrees).

STS-28A Bearing Protector

The bearing protector was sooted along the entire length and circumference (Figures 51 through 53). Slightly heavier soot and erosion were observed in line with the cowl ring vent holes at the thickened portion, but there was no bearing protector burn-through. The largest erosion was 0.162 inch at 90 degrees. There was no evidence of heat effect on the Inside Diameter (ID) surface of the bearing protector.

STS-28A Flex Bearing

Examination of the flex bearing revealed no damage, soot, heat effect, or flow indications (see Figures 54 and 55). All rubber pads, metal shims, and end rings appeared to be in nominal condition. Subsequent refurbishment and testing has verified that the flex bearing is acceptable for reuse.

4.1.2 STS-28A Nozzle Internal Joints

Descriptions of the STS-28A nozzle internal joints follows.

STS-28A Aft Exit Cone-to-Forward Exit Cone (Joint No. 1)

A cross-sectioned view of the STS-28A aft exit cone-to-forward exit cone field joint is presented in Figure 56. Photographs of the postflight joint are shown in Figures 57 through 62.

The backfilled RTV extended below the joint char line circumferentially 360 degrees. The backfill also reached the high pressure side of the primary O-ring from 140-to-150, 180-to-190, and 220-to-0 degrees. The primary O-ring did not see pressure.

Examination of the joint showed a foreign powdery residue (see Figure 63) appearing between 265 and 271 degrees, and a small pin-hole (0.10 inch inboard of housing) at 268 degrees was found on the surface of the aft exit cone polysulfide filled groove between the primary and secondary O-ring groove. This residue was determined to be silica and silicon with traces of salt.

The aft flange of the forward exit cone was scratched at the 91.8-degree location by a guide pin during aft exit cone demate. The scratch was approximately 0.002 inch deep axially, 0.25 inch long circumferentially and 0.02 inch wide radially.

STS-28A Throat-to-Forward Exit Cone (Joint No. 4)

A cross-sectioned view of the STS-28A throat-to-forward exit cone joint is presented in Figure 64. Photographs of the postflight joint are shown in Figures 65 through 70.

The RTV backfill extended below the joint char line and reached to the chamfer 360 degrees circumferentially. RTV reached the high pressure side of the primary O-ring from 287-to-318 degrees. There were no blowpaths in the joint.

Minor corrosion and pitting were observed on the forward end of the forward exit cone at the adhesive/metal interface intermittently around the circumference. There was no metal damage observed.

Intermittent light surface rust was observed on the aft end of the throat support housing at the adhesive/metal interface. Rust stains were also found on the CCP and GCP from 30-to-43 degrees. There was no pitting observed on the metal surfaces.

STS-28A Nose Inlet-to-Throat (Joint No. 3)

A cross-sectioned view of the STS-28A nose inlet/throat joint is presented in Figure 71. Photographs of the postflight joint are shown in Figures 72 through 77.

The RTV backfill extended below the joint char line 360 degrees circumferentially. RTV completely filled the radial ID portion of the joint circumferentially except at 288 degrees. RTV did not reach the high pressure side of the primary O-ring. The primary O-ring did not see pressure.

Aluminum oxide corrosion was observed on the aft end of the aluminum nose inlet housing inboard of the primary O-ring around 75 percent of the circumference, but no pitting was observed. There was no corrosion on the forward end of the steel throat support housing. No metal damage was observed.

STS-28A Nose Inlet-to-Bearing Forward End Ring-to-Cowl (Joint No. 2)

A cross-sectioned view of the STS-28A nose inlet/forward end ring/cowl joint is presented in Figure 78. Photographs of the postflight joint are shown in Figures 79 through 87.

The RTV extended below the joint char line 360 degrees circumferentially and reached the axial portion of the joint approximately 80 percent circumferentially. The radial bondline between the nose cap and cowl showed RTV mixed with the EA913 NA adhesive 360 degrees circumferentially. The adhesive was typically sandwiched between two layers of RTV. There was no RTV extending to the primary O-ring. One blow path was observed at 318 degrees (see Figure 88), but terminated within the RTV. Soot was observed between the adhesive and RTV 360 degrees circumferentially. Sooting also extended onto the nose inlet housing aft end from 282-to-0-to-54 degrees and reached the primary O-ring from 282-to-342 degrees. Sooting at 324-to-336 degrees was found on the OD of the O-ring groove. The primary O-ring saw pressure, but there was no evidence of blowby, erosion, or heat effect. No soot was observed between the aft face of the forward end ring flange and the forward face of the cowl housing, but these surfaces were wet.

Minor corrosion was observed on the aluminum nose inlet housing surface, but no rust was noted on the forward end ring flange. Minor corrosion was also found on the aluminum cowl housing intermittently around the circumference, but no pitting was observed. There was no damage found on the metal surfaces.

STS-28A Fixed Housing-to-Bearing Aft End Ring (Joint No. 5)

A cross-sectioned view of the STS-28A aft end ring/fixed housing joint is presented in Figure 89. Photographs of the postflight joint are shown in Figures 90 through 95.

RTV filled the radial gap between the bearing protector and inner boot ring 360 degrees circumferentially and filled approximately 50 percent of the axial portion of the joint. RTV reached the high-pressure side of the primary O-ring at 10-to-20 and 120-to-125 degrees. There were no blowpaths observed in the joint.

Heavy rust was found on the aft end ring aft tip on approximately 50 percent of the surface. No pitting was observed. Rust stains were also observed on the axial portion of the fixed housing. No metal damage was found.

4.2 STS-28A RH Nozzle/Flex Bearing

Overall erosion of the STS-28B forward nozzle assembly CCP ablative liners was smooth and uniform. All CCP delaminations, wedgeouts, and pop-ups were determined to be postburn occurrences. Soot was observed in Joint 2 up to the primary O-ring, but there was no blowby, erosion, or heat effect to the primary O-ring.

postflight subassembly flow surface gaps are shown in Figure 96. Overall views of the nozzle are shown in Figures 97 through 100.

4.2.1 STS-28B Nozzle Components

STS-28B Aft Exit Cone Assembly

An overall view of the STS-28B aft exit cone fragment is shown in Figure 101.

The aft exit cone was severed aft of the compliance ring by the LSC. The nozzle severance system performance was nominal. The exit cone cut was clean, with no unusual tearing or breaking. The remaining aft exit cone fragment showed missing CCP liner 360 degrees circumferentially. This is a typical postflight observation and occurs at LSC firing and during splashdown. GCP plies exposed by the missing liner showed no signs of heat effect. Missing GCP plies on the aft 6 inches of the exit cone stub exposed six small air voids in the EA946 bondline. The maximum size of the voids was approximately 4 inches axially by 2 inches circumferentially. These voids have been observed on previous postflight exit cones and are inherent to the aft exit cone bonding process.

There were no separations between the polysulfide and the aft exit cone shell observed. postflight measurements of the polysulfide groove radial width (see Table 9) showed that the GCP insulator did not pull away from the aluminum shell during cool-down. The average postflight radial width of the polysulfide groove was 0.18 inch. The polysulfide appeared to have shrunk axially aft up to 0.08 inch. There were no loose layers of polysulfide observed in the groove.

There were no separations observed within the GCP insulator on the forward end.

STS-28B Forward Exit Cone Assembly

The forward exit cone showed missing CCP liner over the center 15 inches of the cone 360 degrees circumferentially. This is a typical postflight observation and occurs at splashdown and during Diver Operated Plug (DOP) insertion. The GCP insulator exposed by the missing liner showed no signs of heat effect. Postburn wedgeouts of charred CCP were observed on the forward 0.8 inch of the intact CCP liner at 0 and 340 degrees. These wedgeouts measured 11 and 12 inches long circumferentially, respectively, and approximately 0.7 inch deep radially. Typical dimpled erosion was observed on the intact liner aft 10 inches and measured approximately 0.1 inch deep radially.

The aft end of the forward exit cone showed bondline separations between the EA946 adhesive and steel housing intermittently around the circumference. The maximum radial width of the separations was 0.02 inch. Bondline separations on the forward end of the forward exit cone were noted between the steel shell and the EA946 adhesive 360 degrees circumferentially. Figure 102 lists the location and radial width measurements of all separations on the forward exit cone. These are typical observations which occur postburn.

Photographs of the sectioned forward exit cone liner are presented in Figures 103 through 105. Char and erosion analysis of the sections is presented in Table 10. All margins of safety were positive, with a minimum of 0.04 occurring at station 28 (90 degrees).

STS-28B Throat Assembly

The throat postflight mean diameter was 55.965 inches (erosion rate of 8.71 mils/second based on an action time of 120.8 seconds). RSRM nozzle postburn throat diameters have ranged from 55.787 to 56.048 inches. The flow surface bondline gap between the throat and throat inlet rings was 0.18 inch and is typical of past static test and flight nozzles.

The throat and throat inlet rings eroded smoothly with no pockets or major washes observed. The forward 1.3 inches of the throat ring showed popped-up charred CCP material intermittently around the circumference. Sharp edges indicate the popped-up material occurred after motor operation. Intermittent postburn impact marks were noted on the throat ring. Marks resulting from DOP insertion were observed on the throat ring intermittently around the circumference.

Bondline separations on the aft end of the throat ring between the EA913 NA adhesive and the steel throat support housing were observed 360 degrees circumferentially with a radial separation of 0.035 inch. The forward end of the throat inlet ring showed metal-to-adhesive bondline separations at 0-to-105, 120-to-210, and 225-to-345 degrees, with 0.02 inch maximum radial separation. Figure 106 lists the location and radial width of the measurements. These separations are typical observations seen on previous test and flight nozzles and occur postburn.

Photographs of the sectioned throat assembly liner are presented in Figures 107 through 110. Char and erosion analysis of the sections is presented in Table 11. All margins of safety were positive, with a minimum of 0.05 occurring at station 8 (90 and 180 degrees).

STS-28B Nose Inlet Assembly

The ply angle of the forward nose ring was checked and found to be of the RSRM design. The flow surface bondline gap between the forward nose (-503) ring and the aft inlet (-504) ring was 0.18 inch. The flow surface bondline gap between the -503 ring and nose cap was 0.05 inch. These postfired measurements are typical of past static test and flight nozzles.

The -503 and -504 rings showed smooth erosion with no pockets or major washes observed. Intermittent small wash areas (maximum radial depth of 0.10 inch) were observed on the -503 forward nose ring.

The nose cap exhibited typical minor wash areas on the forward 24 inches 360 degrees circumferentially (0.15 maximum radial depth). The aft 2-to-3 inches of the nose cap showed typical popped-up, charred CCP liner and postburn wedgeouts intermittently around the circumference. These measured approximately 0.7 inch deep radially at the cowl interface.

The aft end of the nose inlet assembly (-504 ring aft end) showed metal-to-adhesive bondline separations measuring 0.01 inch wide radially from 45-to-270 degrees. There were no bondline separations observed on the aft end of the nose cap. Figure 111 lists the location and radial width measurements of all separations on the nose inlet assembly. These separations are typical observations seen on previous static test and flight nozzles and occur postburn.

Photographs of the sectioned nose inlet assembly rings are presented in Figures 112 through 119. Char and erosion analyses of the sections are presented in Tables 12 and 13. All margins of safety were positive, with a minimum of 0.19 occurring at station 39 (90 and 180 degrees) for the -503/-504 rings, and 0.04 occurring at station 24 (270 degrees) for the nose cap.

STS-28B Cowl Ring

All cowl vent holes appeared plugged with soot and slag on the OD of the ring except at 50, 80, and 110 degrees. These unplugged cowl vent holes were located at wedgeout locations.

The cowl ring showed typical ridged erosion intermittently around the part circumference. The forward portion of the ring eroded a maximum of 0.15 inch greater than the aft portion. This is a result of the low ply angle of the cowl ring and has been observed on the majority of flight and static test nozzles. Wedgeouts and popped-up charred CCP liner were observed on the aft 2 inches of the cowl ring intermittently around the circumference.

The maximum radial depth of the wedgeout was 0.7 inch at the outer boot ring interface.

There were no bondline separations on the forward end of the cowl ring.

Photographs of the sectioned cowl ring are presented in Figures 120 through 123. Char and erosion analysis of the sections is presented in Table 14 (Stations 0 through 7). All margins of safety were positive, with a minimum of 0.22 occurring at station 2 (270 degrees).

STS-28B Outer Boot Ring/Flex Boot

The bondline between the outer boot ring and cowl ring remained intact with no indications of flow. The flow surface bondline gap was 0.20 inch and is typical of past static test and flight nozzles.

The structural backup outer boot ring was intact. The flow surfaces showed smooth erosion with no pockets or major washes. One postburn wedgeout of charred CCP material was observed on the OBR forward 1.5 inches at 172 degrees. The wedgeout measured 3.8 inches circumferentially, with a maximum radial depth of 0.35 inch. Delaminations of charred CCP along the 35-degree plies were observed on the flow surface. Typical wedgeouts or charred CCP were also found on the aft tip adjacent to the flex boot.

Photographs of the sectioned outer boot ring are presented in Figures 124 through 127. Char and erosion analysis of the sections is presented in Table 14 (Stations 8 through 11.3). All margins of safety were positive, with a minimum of 0.07 occurring at station 9 (90 degrees).

The cavity side of the flex boot was evenly sooted and showed no evidence of flow or erosion (Figures 128 through 130). It appeared typical of previous flight and static test motor flex boots. A minimum of 3.25 NBR plies remained around the circumference after motor burn. Table 15 presents the flex boot material affected depths and Performance Margins of Safety. The worst-case PMS was 0.26 at 270 degrees.

STS-28B Fixed Housing Assembly

The fixed housing insulation showed smooth erosion with no pockets or major washing observed. Postburn wedgeouts of charred CCP material were observed on the forward 2.0 inches of the fixed housing insulation intermittently around the circumference. The wedgeouts were a maximum of 0.5 inch deep radially. There was no heat effect to the GCP.

There were no bondline separations observed on the forward end or aft end.

Photographs of the sectioned fixed housing assembly liner are presented in Figures 131 through 134. Char and erosion analysis of the sections is presented in Table 16. All margins of safety were positive, with a minimum of 0.27 occurring at station 10.75 (90 degrees).

STS-28B Bearing Protector

The bearing protector was sooted along the entire length and circumference (see Figures 135 through 137). Heavier soot and erosion were observed in line with the cowl ring vent holes at the thickened portion of the bearing protector. The greatest erosion was 0.06 inch at 40 degrees. There was no evidence of heat effect on the ID surface of the bearing protector.

STS-28B Flex Bearing

Visual examination of the flex bearing revealed no damage, soot, heat effect, or flow indications (see Figures 138 and 139). All rubber pads, metal shims, and end rings appeared to be in nominal condition. Subsequent testing has shown an unacceptable unbond area. This was written up on DR 165119. Acceptance tests have not been completed.

4.2.2 STS-28B Nozzle Internal Joints

Descriptions of the STS-28 nozzle internal joints follow.

STS-28B Aft Exit Cone-to-Forward Exit Cone (Joint No. 1)

A cross-sectioned view of the STS-28B aft exit cone-to-forward exit cone field joint is presented in Figure 140. Photographs of the postflight joint are shown in Figures 141 through 146.

The backfilled RTV extended below the joint char line 360 degrees circumferentially. The RTV backfill extended to the high pressure side of the primary O-ring from 0-to-8, 63-to-67, 78-to-86, 97-to-120, 288-to-292, and 300-to-322 degrees. There were no blowpaths observed in the joint, and the primary O-ring saw no pressure.

Light aluminum oxide corrosion was observed on the aft exit cone forward end between the primary and secondary O-ring grooves intermittently around the circumference. Heavier corrosion was observed on the forward OD corner of the aft exit cone shell intermittently around the circumference. Pitting was observed at these locations, but it could not be determined if the pitting resulted from this or previous flights. Light rust was also observed on the forward exit cone aft end between the O-ring footprints, intermittently around the circumference.

Minor displaced metal was observed on the forward exit cone at the 91.8-degree alignment pin-hole due to disassembly contact with the alignment pin (see Figure 147). The displaced metal measured approximately 0.01 inch axially by 0.01 inch circumferentially by 0.28 inch radially.

STS-28B Throat-to-Forward Exit Cone (Joint No. 4)

A cross-sectioned view of the STS-28 throat-to-forward exit cone joint is presented in Figure 148. Photographs of the postflight joint are shown in Figures 149 through 154.

The RTV backfill extended below the joint char line 360 degrees circumferentially and extended on to the radial OD portion of the joint at 0-to-165, 172-to-200, and 308-to-0 degrees. RTV extended on to the axial portion of the bondline from 200-to-235 degrees and 263-to-308 degrees. RTV did not reach the high-pressure side of the primary O-ring. The primary O-ring saw no pressure or evidence of blowby, erosion, or heat effect. The GCP also showed no signs of heat effect.

Rust was observed on the throat housing at the adhesive/metal interface 360 degrees circumferentially, but there was no pitting. Grease coverage was nominal. There was no metal damage observed.

STS-28B Nose Inlet-to-Throat (Joint No. 3)

A cross-sectioned view of the STS-28 nose inlet-to-throat joint is presented in Figure 155. Photographs of the postflight joint are shown in Figures 156 through 161.

The RTV backfill extended below the joint char line 360 degrees circumferentially. RTV did not reach the high pressure side of the primary O-ring. RTV also extended onto the axial portion of the joint on approximately 50 percent of the circumference. The primary O-ring did not see pressure.

Minor surface corrosion was observed on the aft end of the nose inlet housing inboard of the primary O-ring, but no pitting was observed. There was no corrosion on the forward end of the throat housing.

Inspection of the radial OD portion of the joint showed a wet, black substance measuring approximately 2 inches circumferentially by 0.5 inch radially by 0.04 inch thick axially at 203 degrees (see Figure 162). This substance was located on the radial OD phenolic surfaces of the joint immediately behind the RTV backfill. Upon removal from the surface, it broke apart into a powdery form. The substance appeared fibrous.

In addition, there were no apparent blowpaths in the joint and no signs of heat affected phenolics or RTV in the immediate area of the substance.

Analysis shows the presence of Silicon (Si) - 49 percent, Aluminum (Al) - 17 percent, Magnesium (Mg) - 13 percent (probably from sea water), and Iron (Fe) - 8 percent. Carbon, Hydrogen, Nitrogen (C,H,N) tests were also performed on the samples. The results show 43 percent C, 0.5 percent N, and 1.3 percent H. This material was determined to be a mixture of charred RTV and CCP materials mixed with sea water. This was introduced into the joint during splashdown.

STS-28B Nose Inlet-to-Bearing Forward End Ring-to-Cowl (Joint No. 2)

A cross-sectioned view of the STS-28 nose inlet-to-bearing forward end ring-to-cowl joint is presented in Figure 163. Photographs of the postflight joint are shown in Figures 164 through 172.

The RTV extended below the joint char line and reached to the axial portion of the joint (forward end ring flange) 360 degrees circumferentially. The radial bondline between the nose cap and cowl showed RTV mixed with the EA913 NA adhesive 360 degrees circumferentially. The adhesive was typically sandwiched between two layers of RTV. No RTV extended to the primary O-ring. Soot entered the joint 360 degrees circumferentially and extended past the nose inlet housing bolt holes, but no distinct blowpaths were observed. Soot was observed between the adhesive and RTV intermittently around the circumference. Heavy soot also reached the primary O-ring at 18-to-38, 68-to-84, 162-to-176, 195, 207, 228-to-234, 250-to-258, 264-to-267, 270-to-281, 283-to-288, and 305 degrees. Heavy sooting was from 270-to-0-to-30 degrees and was found on the RTV surface up to the forward end ring flange. The cowl and nose cap SCP and GCP insulators showed no heat effect. The primary O-ring saw pressure, but there was no evidence of blowby, erosion, or heat effect. No soot was observed between the aft face of the forward end ring flange and the forward face of the cowl housing.

Intermittent light corrosion on the aft end of the nose inlet housing adjacent to the bondline was observed. Minor intermittent corrosion was also found on the aluminum cowl housing forward end, but pitting was not present. Intermittent light rust was observed on the flange forward surface of the bearing forward end ring. Paint was also chipped off the OD surface. There was no damage found on the metal surfaces.

STS-28B Fixed Housing-to-Bearing Aft End Ring (Joint No. 5)

A cross-sectioned view of the STS-28B fixed housing-to-bearing aft end ring joint is presented in Figure 173. Photographs of the postflight joint are shown in Figures 174 through 179.

RTV filled the radial portion of the joint 360 degrees circumferentially and reached the high pressure side of the primary O-ring around 80 percent of the circumference. Voids isolated within the RTV were observed on the radial portion of the joint intermittently around the circumference, but none reached the flex boot cavity. There were no blowpaths observed in the joint, and the primary O-ring did not see pressure.

Heavy rust was found on the aft end ring aft tip where paint was chipped off intermittently around the circumference. Minor rust stains were also observed on the axial OD and ID portions of the fixed housing. No metal damage was found.

4.3 Instrumentation

There was no Development Flight Instrumentation installed on the STS-28 nozzles.

5.0 DISCREPANCY REPORTS AND PROCESS DEPARTURES

The STS-28 Nozzle DRs and PDs reviewed by the Morton Thiokol senior material review board are included in Appendix A. These were presented in the STS-28 RSRM Acceptance Review Level III (TWR-). Brief descriptions of the DRs and PDs, and correlations to postflight observations are discussed below.

5.1 STS-28A DRs and PDs

Forward Exit Cone
DR 161110-01, Waiver No.: RWW445

Two LDIs located in the carbon phenolic liner starting at the interface and running parallel to the ply direction. Postflight inspection of this part did not reveal any propagation of the LDIs.

Nozzle Flex Bearing Assembly
DR 169467-02, Waiver No.: None
-03,

Total unbond area of rubber pads exceeds requirements.

The flex bearing passed all of the acceptance tests and postflight refurbishment requirements.

Outer Boot Ring, First Wrap
PD 169735-01, Waiver No.: None

Temperature was held at 220 ± 10 °F for 113 minutes, 23 minutes over maximum allowable. Postflight inspection showed no abnormal erosion.

Outer Boot Ring, First Wrap
PD 169735-02, Waiver No.: None

Temperature was reduced at an overall average rate of 0.689 °F/min. Anomalous cooldown lasted 15 minutes, followed by a 1-hour cooldown at an acceptable rate of 0.5 °F/min maximum.

Postflight inspection showed no abnormal erosion.

Aft Exit Cone Liner
DR 173080-01, Waiver No.: None
02,

LDIs within the GCP larger than 2.5 inches circumferential width, 1.9 inches longitudinal length, or 0.025 inch radial depth are unacceptable. Numerous LDIs exceed one or more of the above dimensions on aft exit cone liner.

Postflight inspection of this part was not possible.

Aft Exit Cone Assembly
DR 173099-01, Waiver No.: None

LDIs within the GCP larger than 2.5 inches circumferential width, 1.9 inches longitudinal length, or 0.025 inch radial depth are unacceptable. Four LDIs exceed one or more of the above dimensions; all classified as ply-end conditions (longitudinal length < 0.200 inch).

Postflight inspection of this part was not possible.

Fixed Housing Assembly
DR 173448-01, Waiver No.: None

Blemish on CCP at 148 degrees (forward ID surface) checks 1.9 inches long, 0.225 inch wide, 0.045 inch deep.

Postflight inspection showed no abnormal erosion.

DR 173448-02

Numerous wetline indications on CCP forward ID.

Postflight inspection showed no abnormal erosion.

5.2 STS 28B DRs and PDs

Outer Boot Ring, First Wrap
PD 169737-01, Waiver No.: None

Temperature was held at 220 ± 10 °F for 113 minutes, 23 minutes over maximum allowable.

Postflight inspection showed no abnormal erosion.

Outer Boot Ring, First Wrap
PD 169737-02, Waiver No.: None

Temperature was reduced at an overall average rate of 0.689 °F/min. Anomalous cooldown lasted 15 minutes, followed by a 1-hour cooldown at an acceptable rate of 0.5 °F/min maximum.

Postflight inspection showed no abnormal erosion.

Flex Bearing Assembly
DR 169782-03, Waiver No.: None

Maximum unbond depth checks 3.4 inches on pad 3.

This flex bearing was written up on DR 165119 for unacceptable unbond area.

Aft Exit Cone Assembly
DR 170806-01, Waiver No.: None

Two areas contain LDIs which exceed limits. Maximum dimensions of any single LDI are 3.78 inches circumferential width.

Postflight inspection of this part was not possible.

Aft Exit Cone Assembly
DR 170806-02, Waiver No.: None

High Density Indication (HDI) with projected area of 0.0675 in.^{2} (0.250 inch longitudinal by 0.270 inch circumferential) located in GCP, 36.14 inches forward of part aft end at 216 degrees. HDI runs parallel to glass ply direction.

Note: Six other HDIs exist in general area of noted HDI. All six have projected areas less than 0.050 in.^{2}.

Postflight inspection of this part was not possible.

Nozzle Compliance Ring

DR 173430-01, Waiver No.: RWW451

Nonlocking helicoil inserts were installed into the compliance ring.

Note: Flight 5A and Flight 6 and subsequent compliance rings have locking helicoil inserts installed.

Postflight inspection did not reveal any flight-related problems with the helicoil inserts.

6.0 NOZZLE COMPONENT PROGRAM TEAM (NCPT) RECOMMENDATIONS AND REDESIGN PROGRAM REVIEW BOARD (RPRB) ASSESSMENT

The NCPT reviewed all observations documented in this report. The team classified two Problem Reports (written at KSC) as minor anomalies. After internal nozzle joint inspections at Clearfield, the team initially classified one observation as a potential anomaly. This was further classified as a minor anomaly. These were presented to the RPRB on 06 September 1989. The RPRB agreed with the classifications. These minor anomalies were recorded on Postfire Anomaly Record (PFAR) forms and are included in Appendix B. The PFARs contain detailed descriptions and corrective actions as accepted and/or modified by the RPRB. A listing of the PFARs is listed below.

6.1 STS-28A Nozzle

PFAR NUMBER	DESCRIPTION
360H005A-03	Foreign residue and a small pin hole found on aft exit cone polysulfide groove fill.
360H005A-08	White, sticky material on fixed housing (aft end) forward of the primary O-ring at the EA913NA interface.

6.2 STS-28B Nozzle

360H005B-13	Black, powdery residue found in Joint 3.

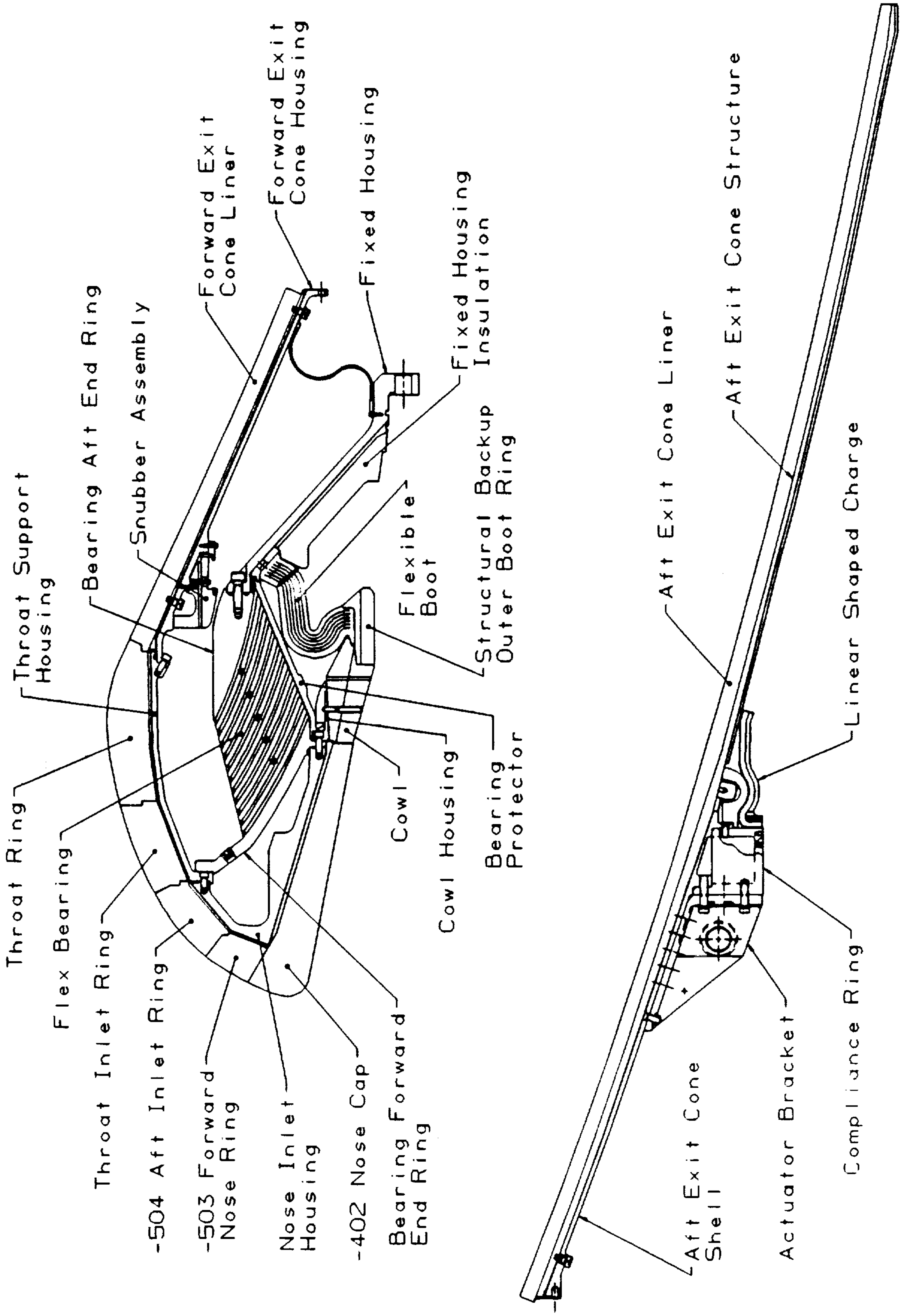
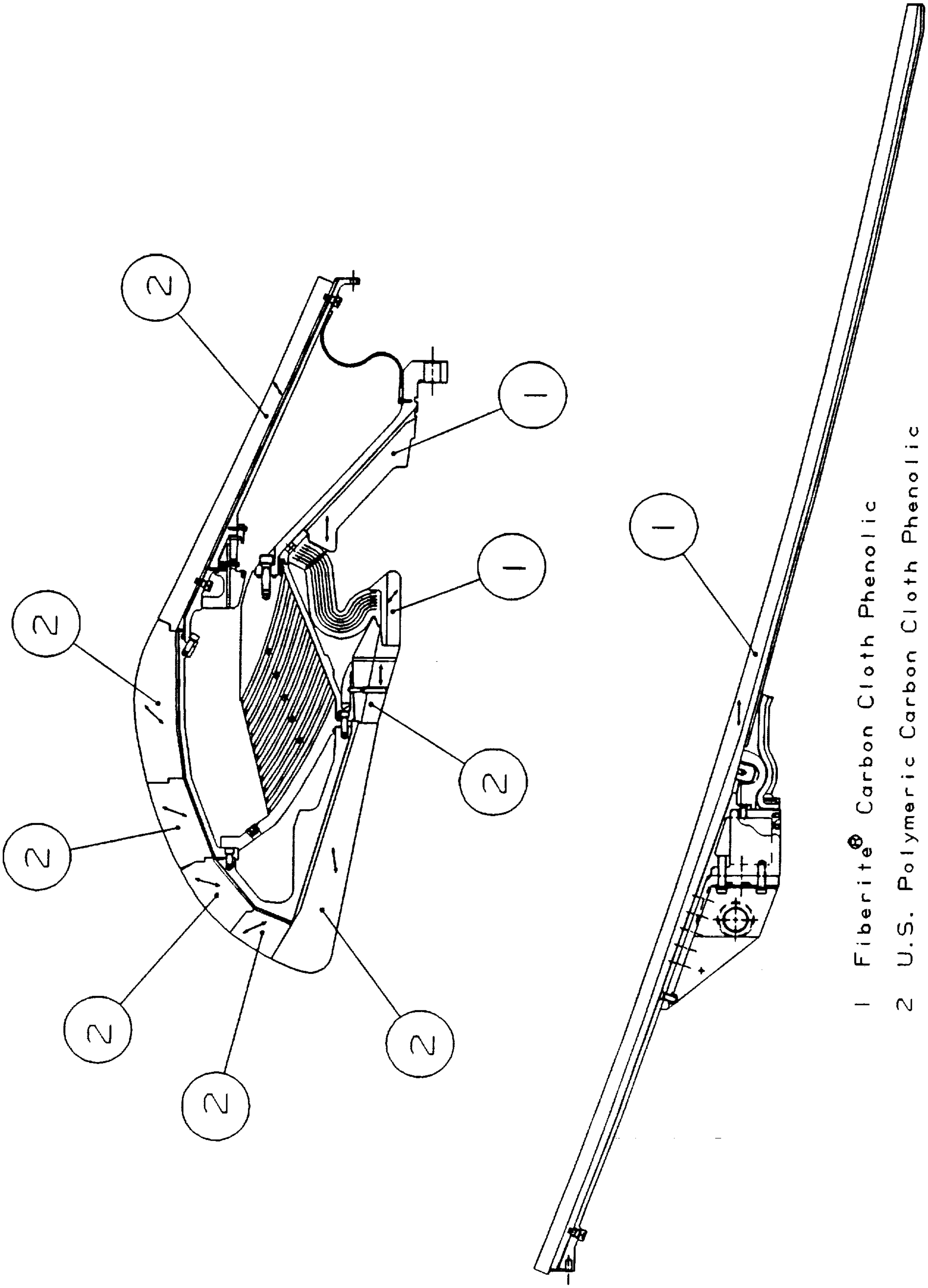


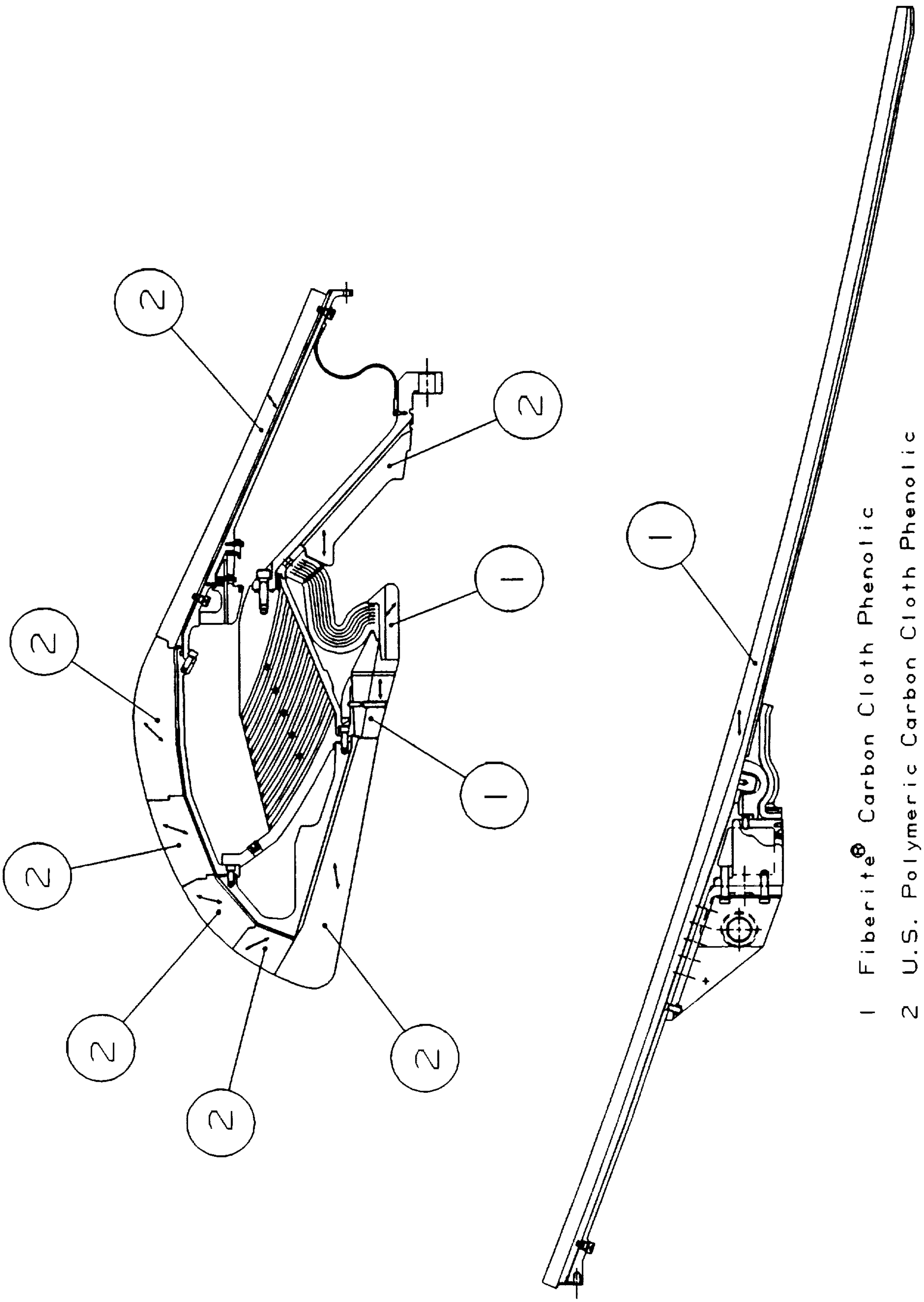
Figure 1 STS-28 Nozzle Components



1 Fiberite® Carbon Cloth Phenolic

2 U.S. Polymeric Carbon Cloth Phenolic

Figure 2 STS-28A Nozzle Material



1 Fiberite® Carbon Cloth Phenolic
2 U.S. Polymeric Carbon Cloth Phenolic

Figure 3 STS-28B Nozzle Material

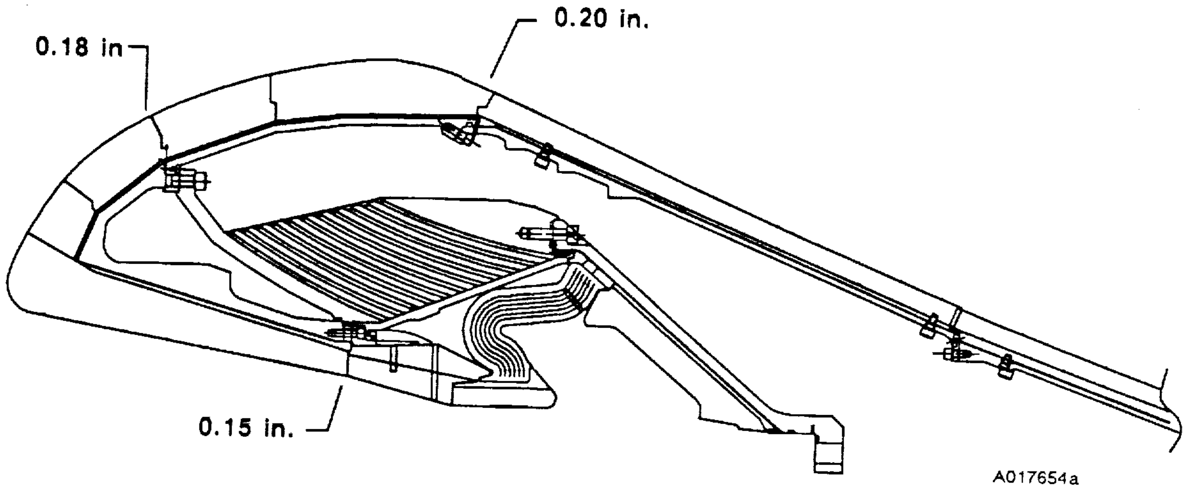


Figure 4 STS-28A Post-Flight Joint Flow Surface Gap Openings

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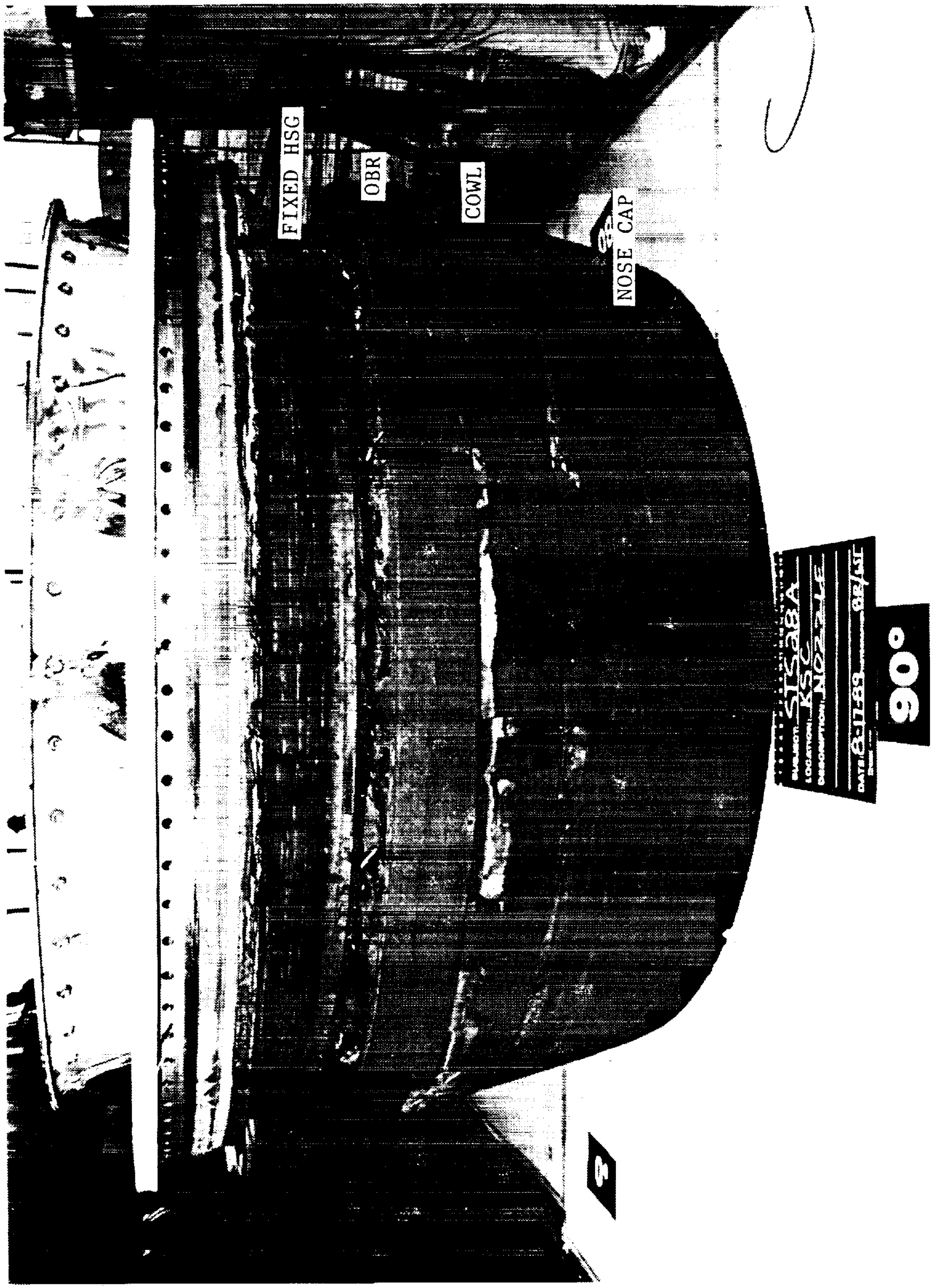

Figure 5 STS-28A Forward Nozzle Assy (External) 0-to-90-to-180 degrees

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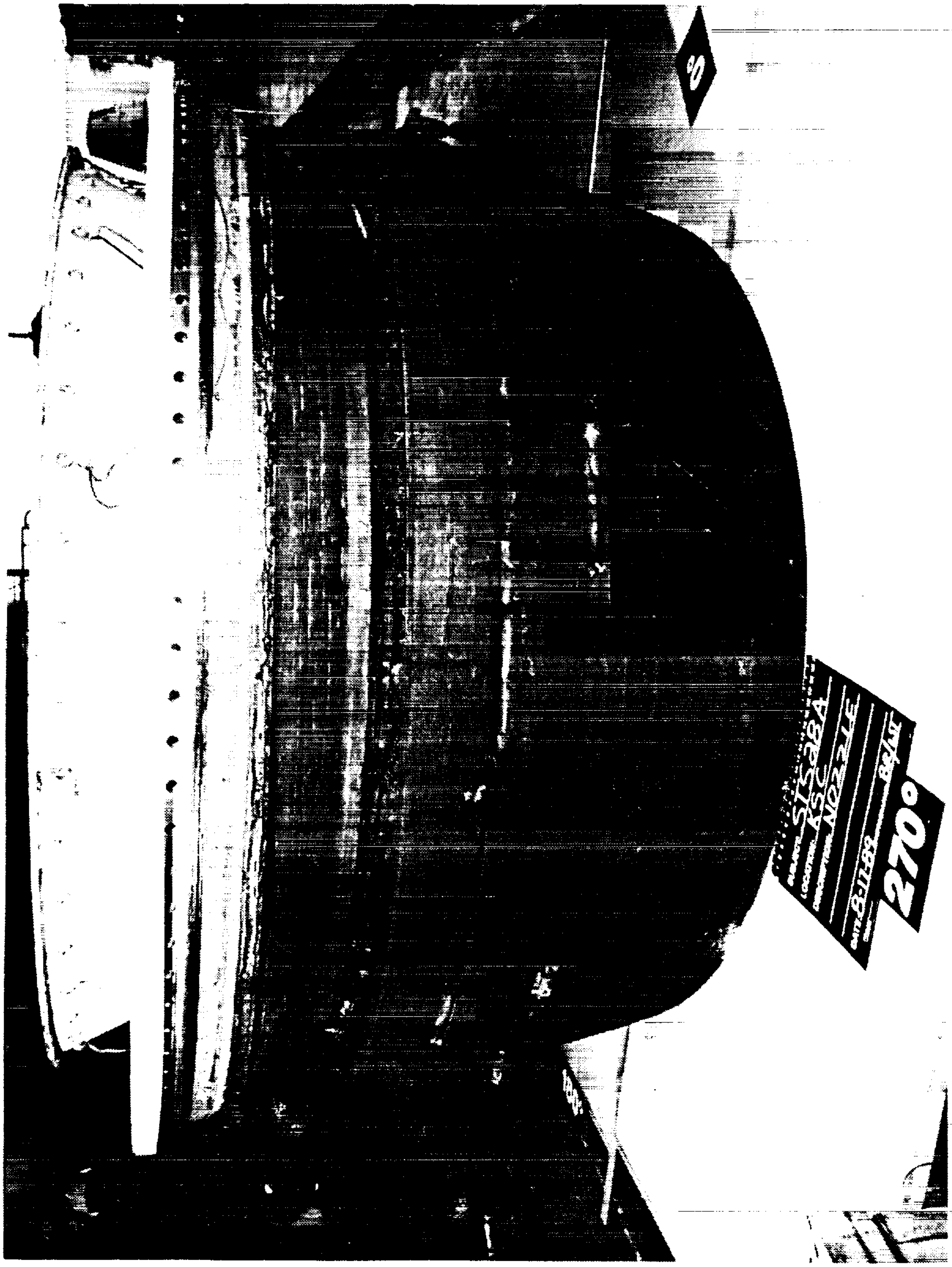

Figure 6 STS-28A Forward Nozzle Assy (External) 180-to-270-to-0 degrees

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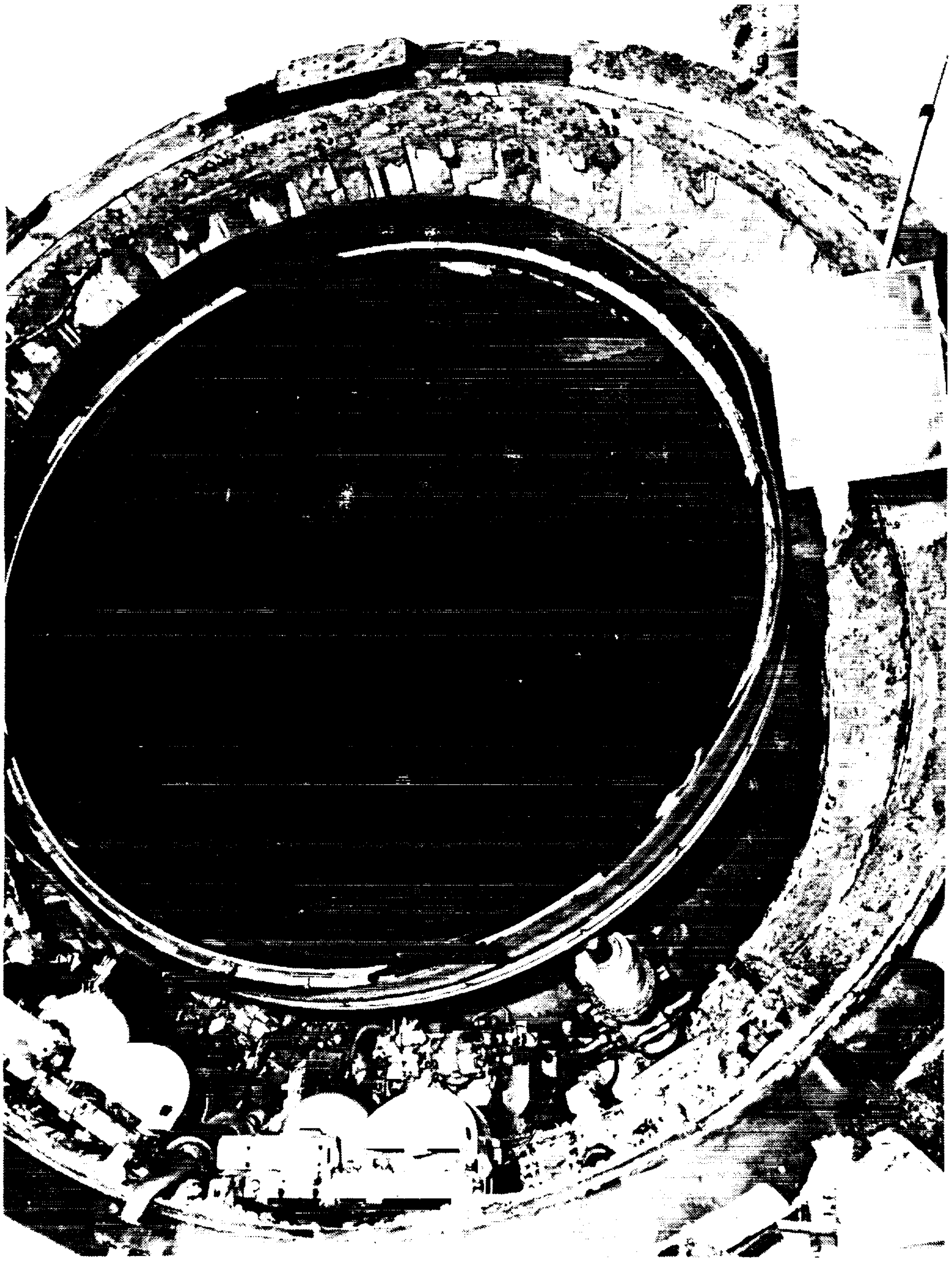
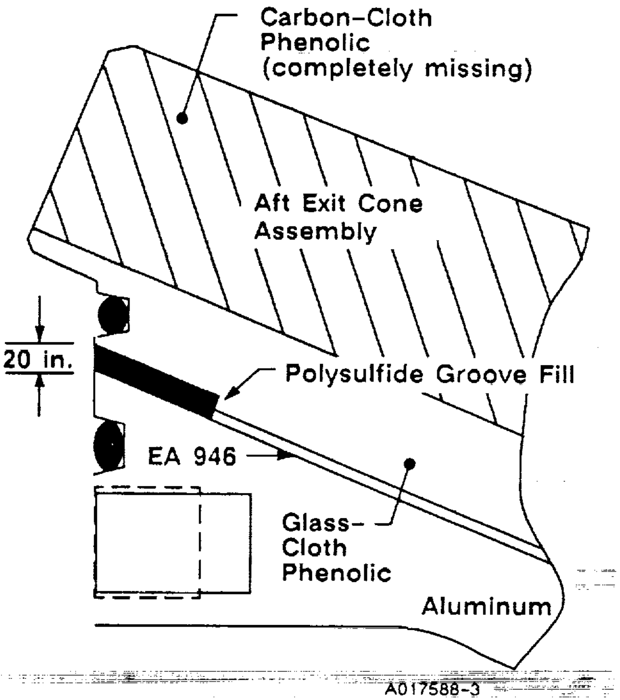
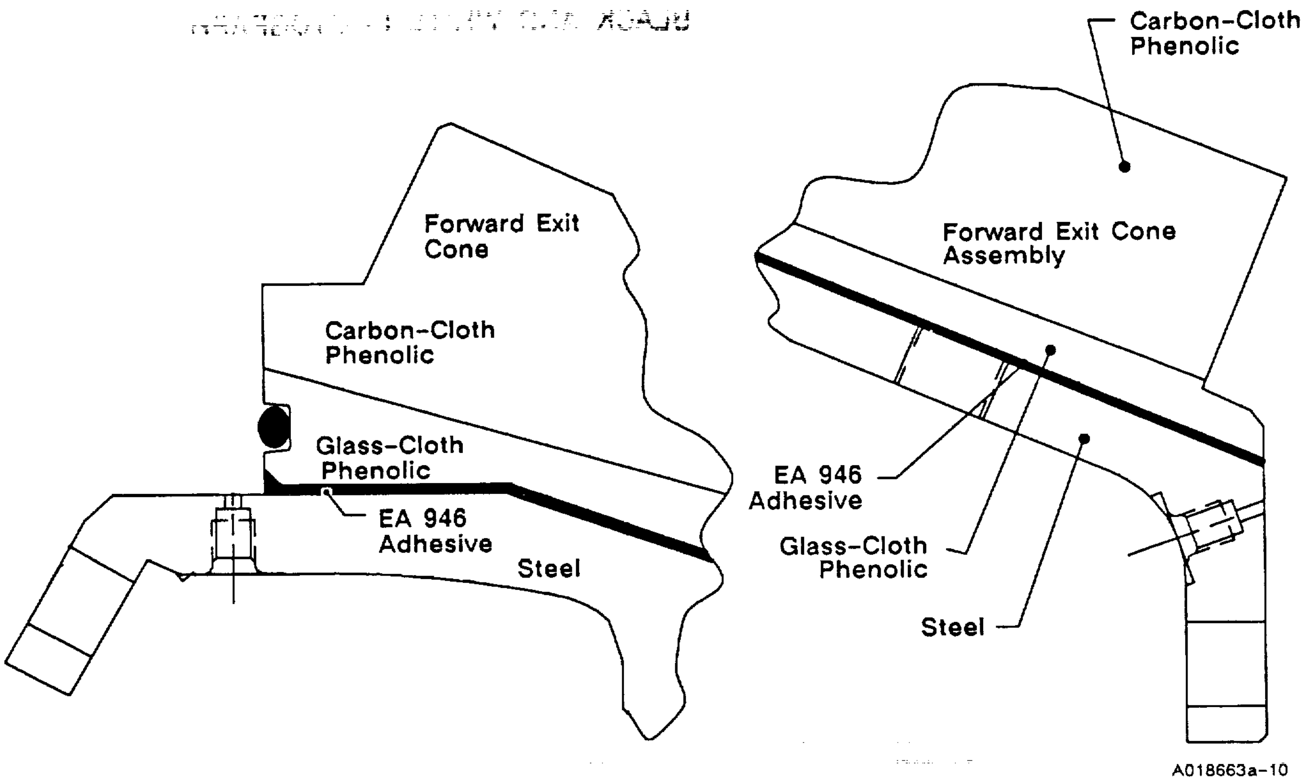


Figure 7 STS-28A Aft Exit Cone Fragment

Table 1 STS-28A Aft Exit Cone Post-Flight Polysulfide Groove Radial Widths



Angular Location (deg)	Width (in.)
0	0.19
30	0.18
60	0.18
90	0.18
120	0.19
150	0.19
180	0.19
210	0.19
240	0.19
270	0.19
300	0.18
330	0.18



Forward End

Location (deg)	Radial Separation (in.)	Separation Type
0-110	0.010	Metal/Adhesive
120	0.030	Metal/Adhesive
140	0.040	Metal/Adhesive
150-300	0.010	Metal/Adhesive
340-0	0.010	Metal/Adhesive
135-150	0.020	Cohesive
0-5	0.015	Glass to Glass
340	0.003	Glass to Glass
345	0.010	Glass to Glass

Figure 8. STS-28A Forward Exit Cone Bondline Separations

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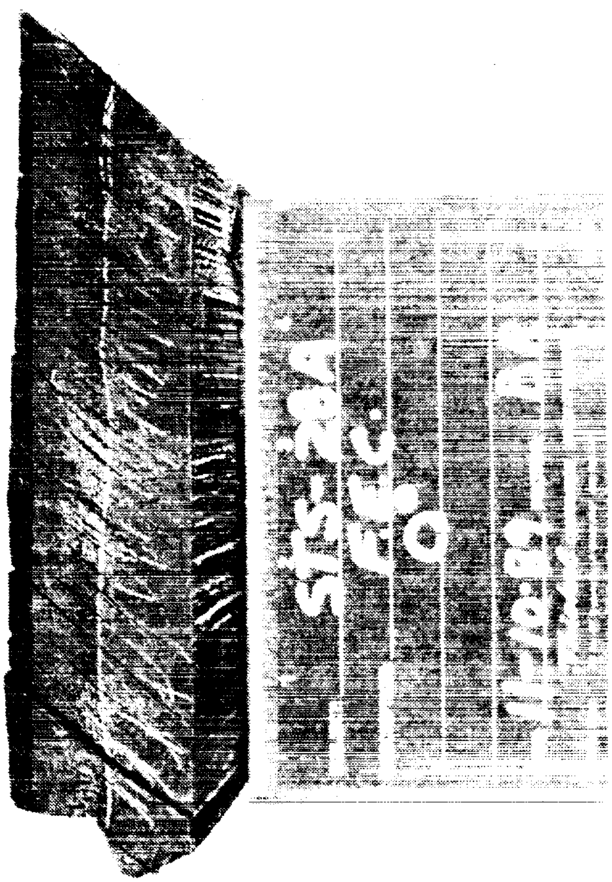

Figure 9 STS-28A Forward Exit Cone Liner Section (0 deg)

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Figure 10 STS-28A Forward Exit Cone Liner Section (90 deg)

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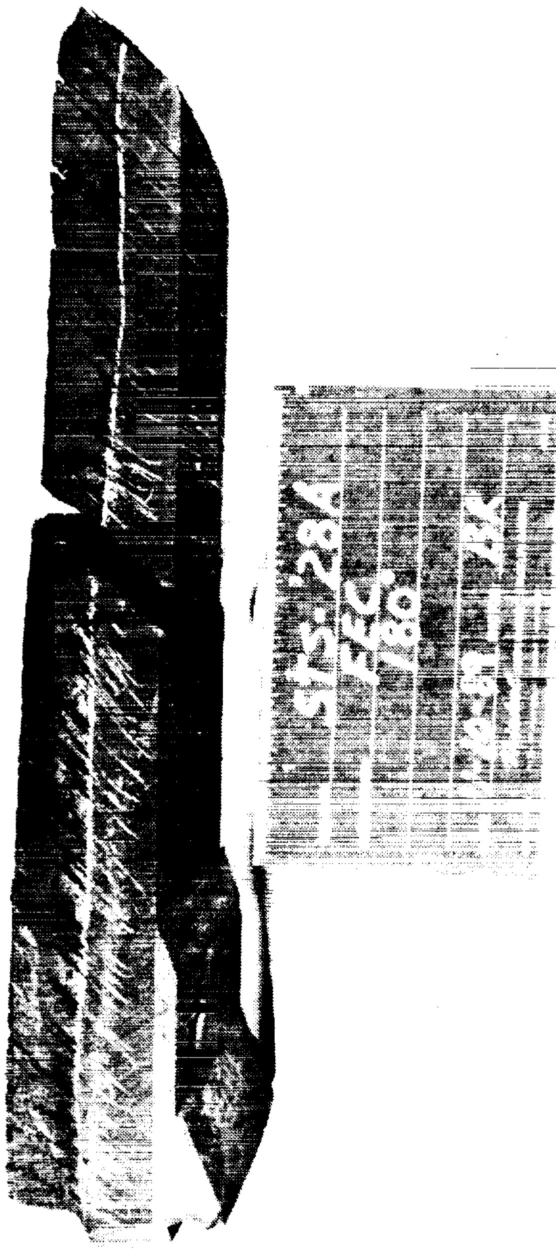

Figure 11 STS-28A Forward Exit Cone Liner Section (180 deg)

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Figure 12 STS-28A Forward Exit Cone Liner Section (270 deg)

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Table 2 STS-28A Forward Exit Cone Erosion and Char Data

Angular Location	Stations									
	1	4	8	12	16	20	24	28	32	34
0 degrees										
Measured Erosion	0.36	0.30	NA	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.69	0.76	NA	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.55	0.61	NA	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.41	1.36	NA	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.28	0.27	NA	NA	NA	NA	NA	NA	NA	NA
90 degrees										
Measured Erosion	0.38	0.35	0.32	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.60	0.59	0.59	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.48	0.47	0.47	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.36	1.29	1.23	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.33	0.34	0.32	NA	NA	NA	NA	NA	NA	NA
180 degrees										
Measured Erosion	0.32	0.32	0.32	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.74	0.77	0.71	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.59	0.62	0.57	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.38	1.41	1.35	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.31	0.23	0.21	NA	NA	NA	NA	NA	NA	NA
270 degrees										
Measured Erosion	0.32	0.33	0.34	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.71	0.65	0.59	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.57	0.52	0.47	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.35	1.31	1.27	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.34	0.32	0.28	NA	NA	NA	NA	NA	NA	NA

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

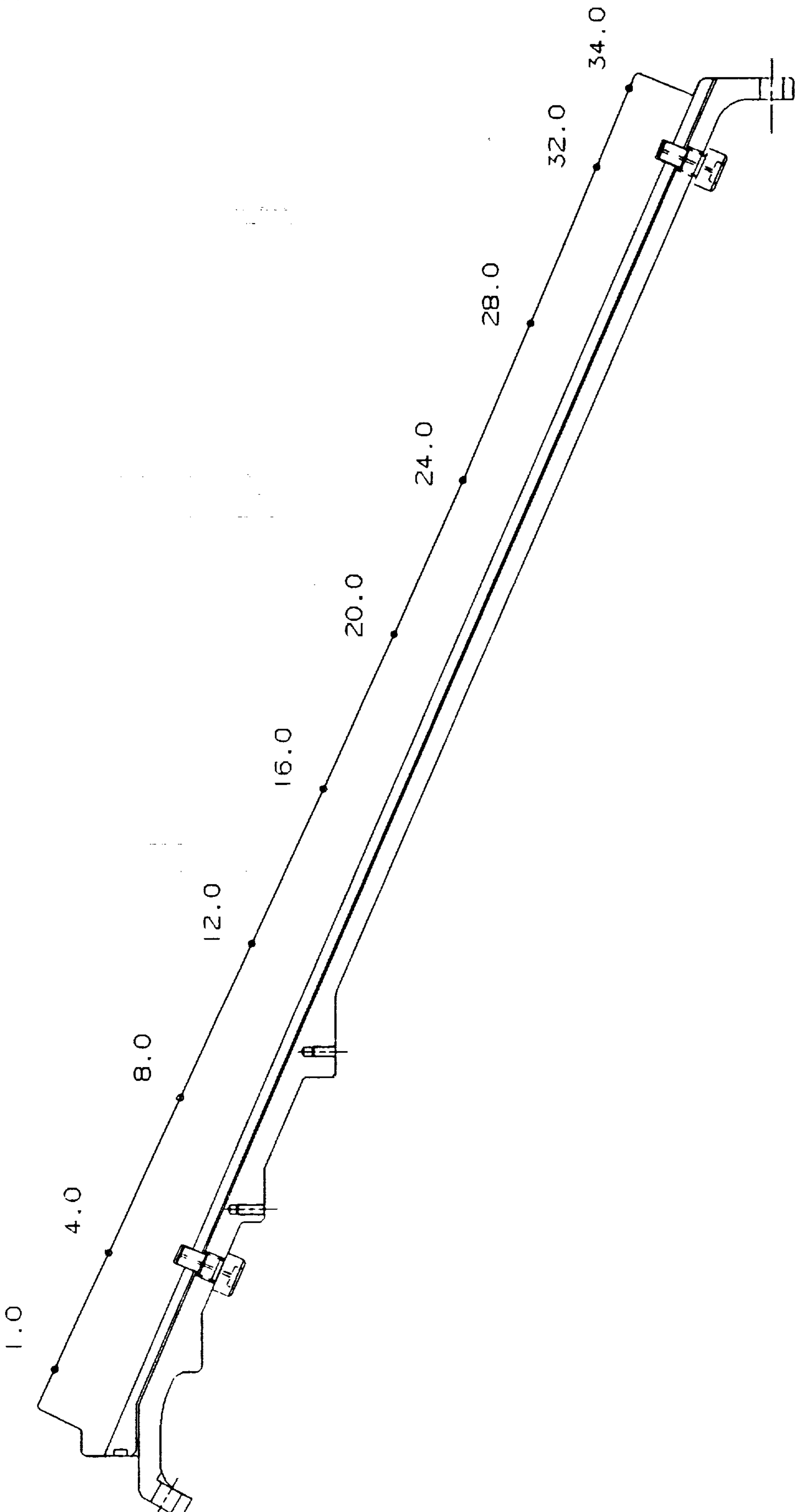
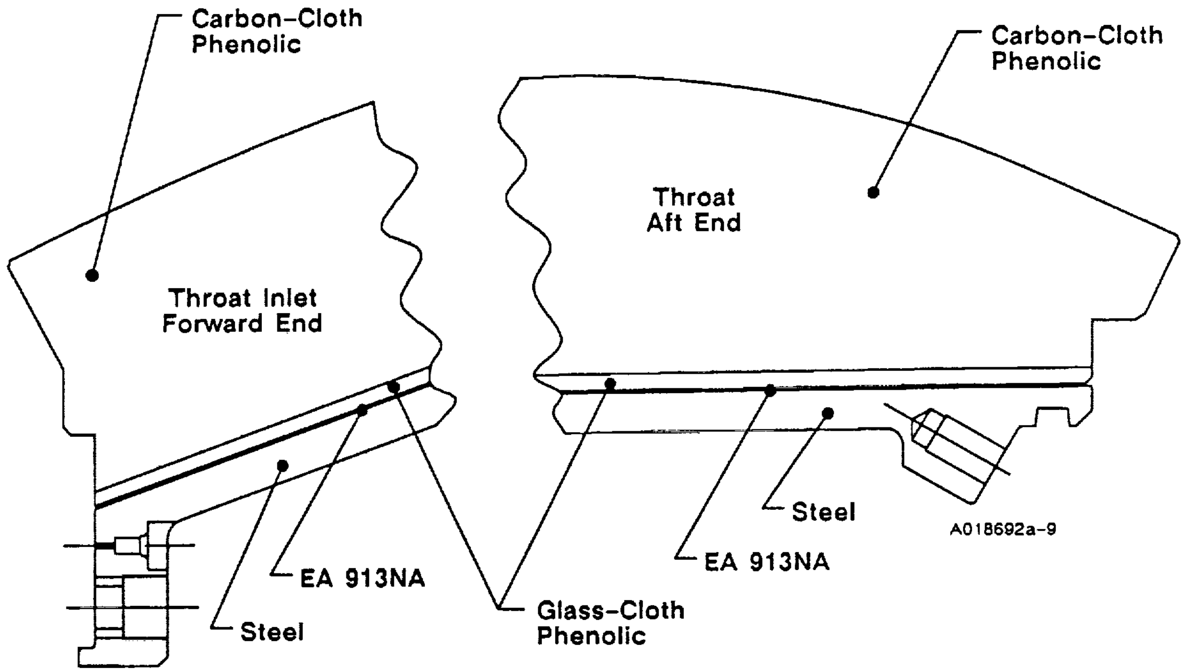


Figure 13 STS-28A Forward Exit Cone Assy Nozzle Stations



Fwd End Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
0	0.010
15	0.020
30	0.030
45	0.020
60	0.010
120	0.010
135	0.020
150	0.010
195-210	0.010
225	0.020
240-255	0.010
345	0.010

Aft End Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
360 Circumferentially	0.040

Figure 14 STS-28A Throat Assembly Bondline Separations

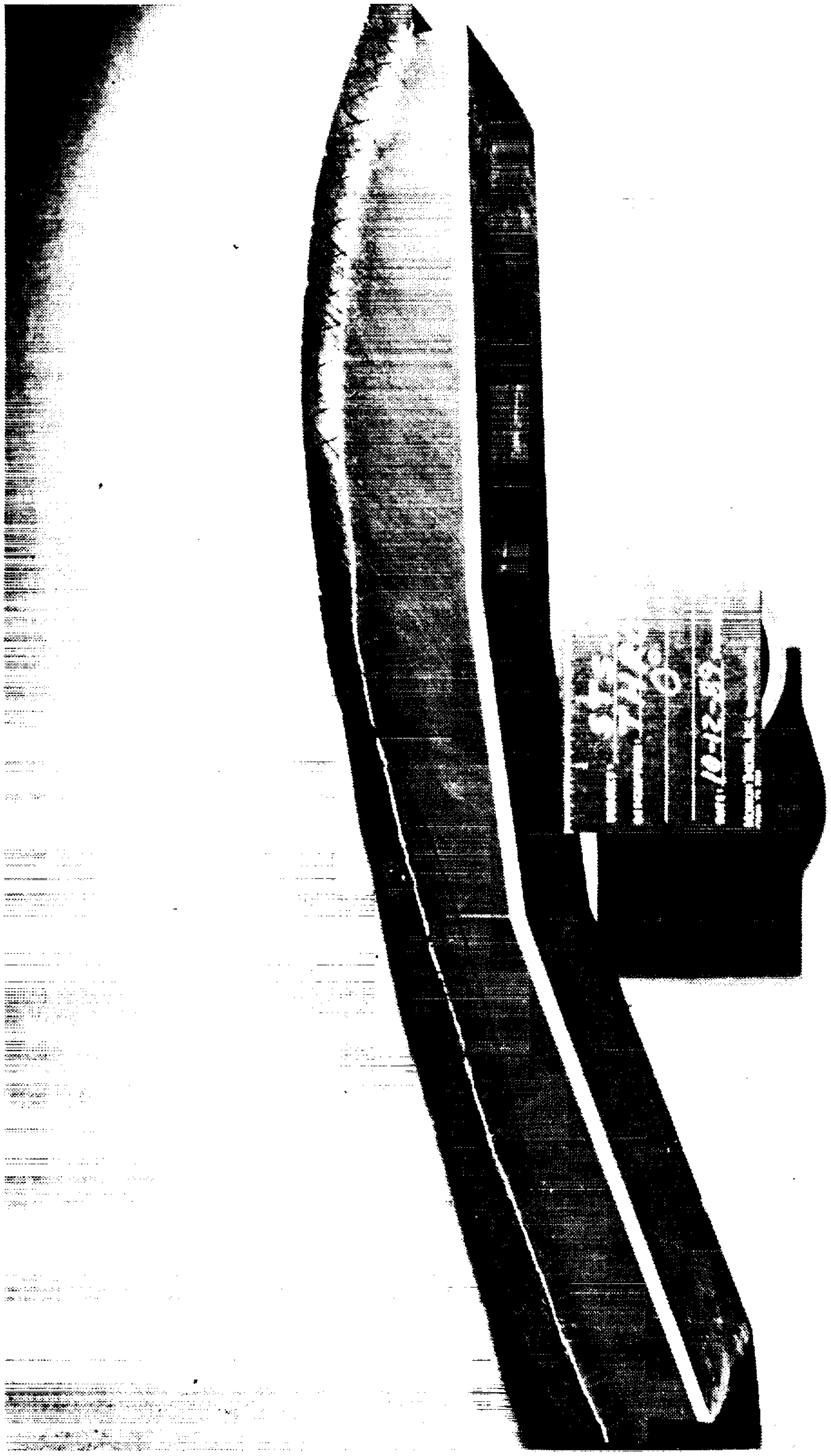


Figure 15 STS-28A Throat/Throat Inlet Section (0 deg)

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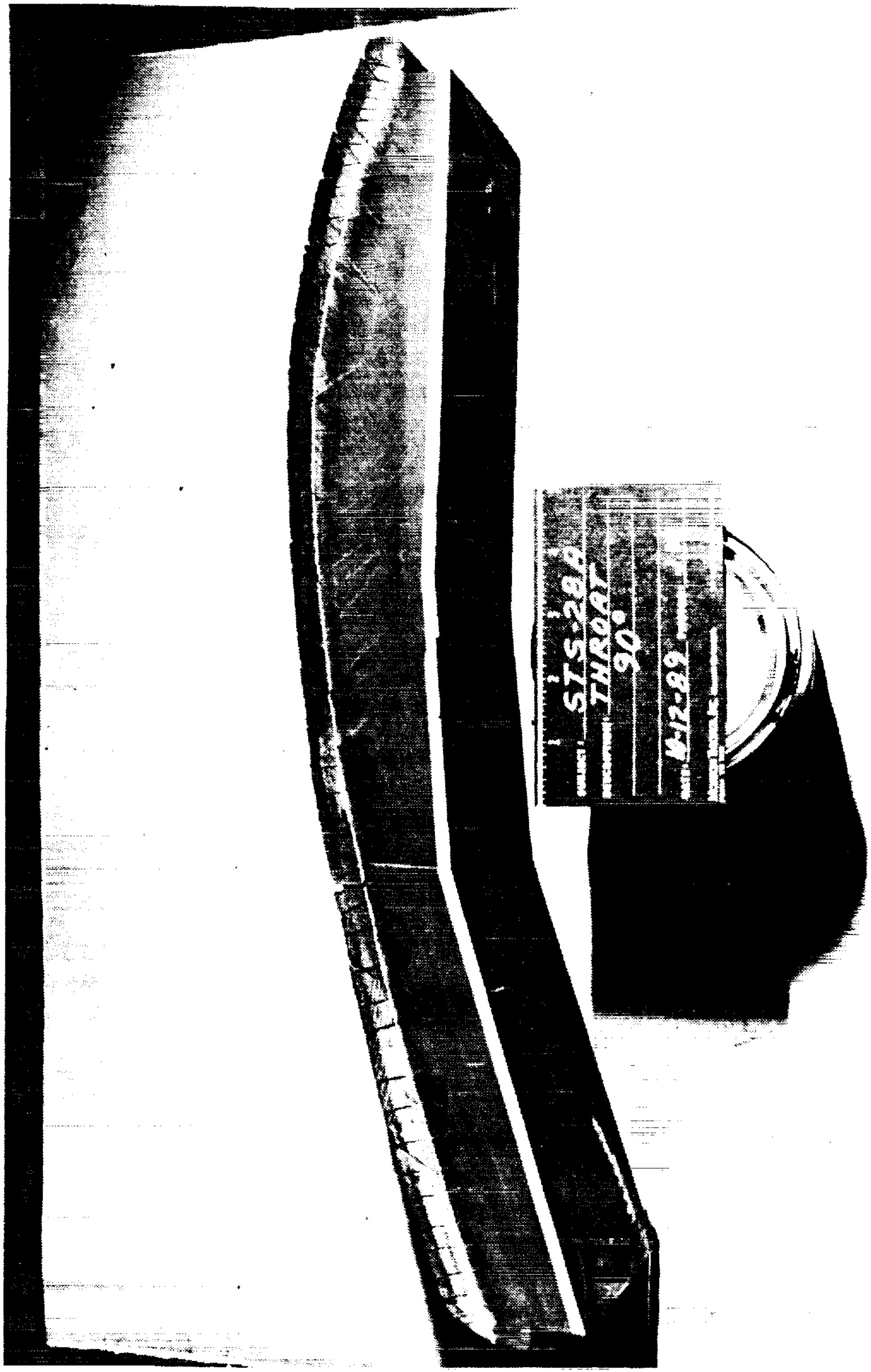

Figure 16 STS-28A Throat/Throat Inlet Section (90 deg)

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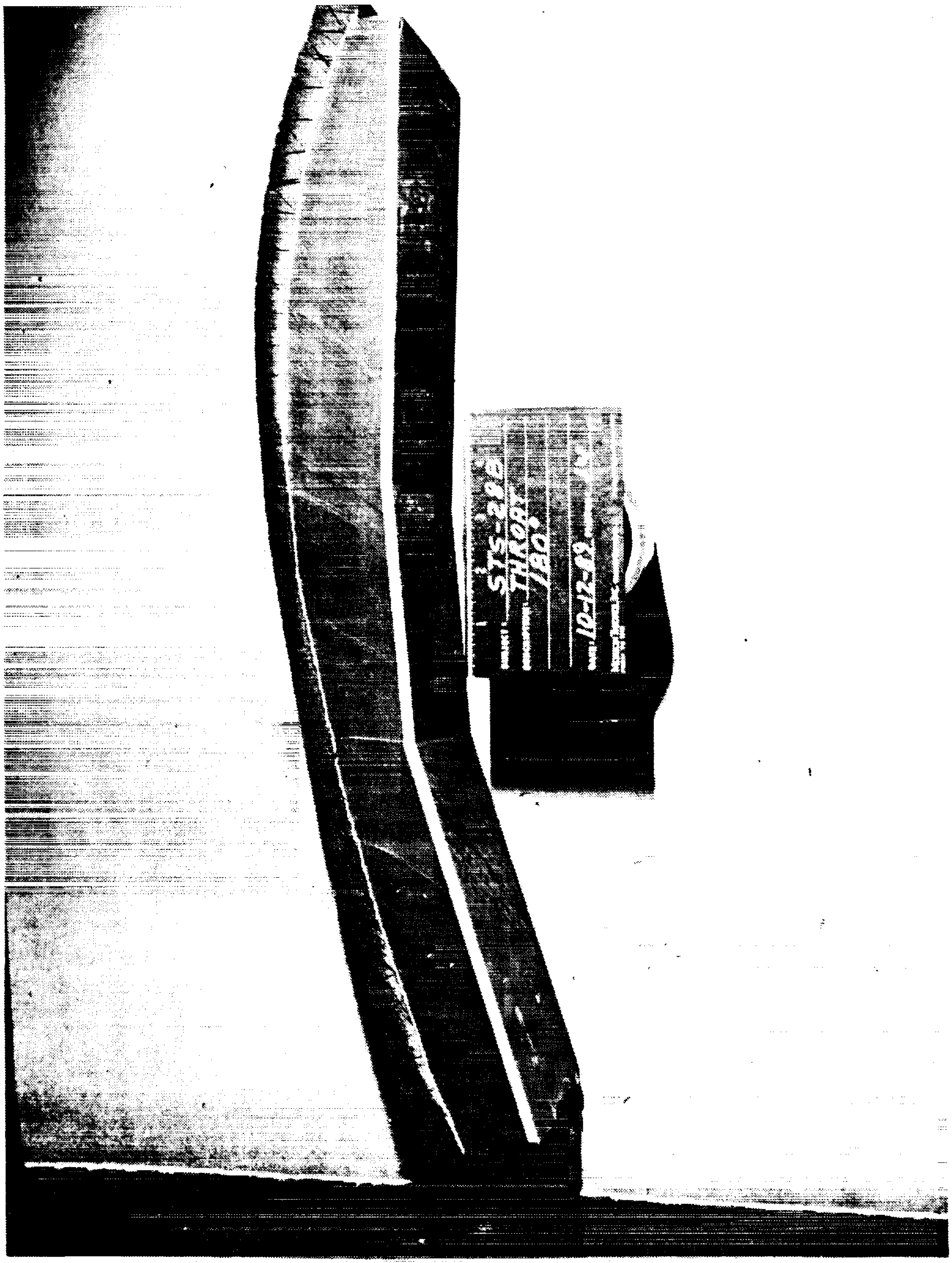

Figure 17 STS-28A Throat/Throat Inlet Section (180 deg)

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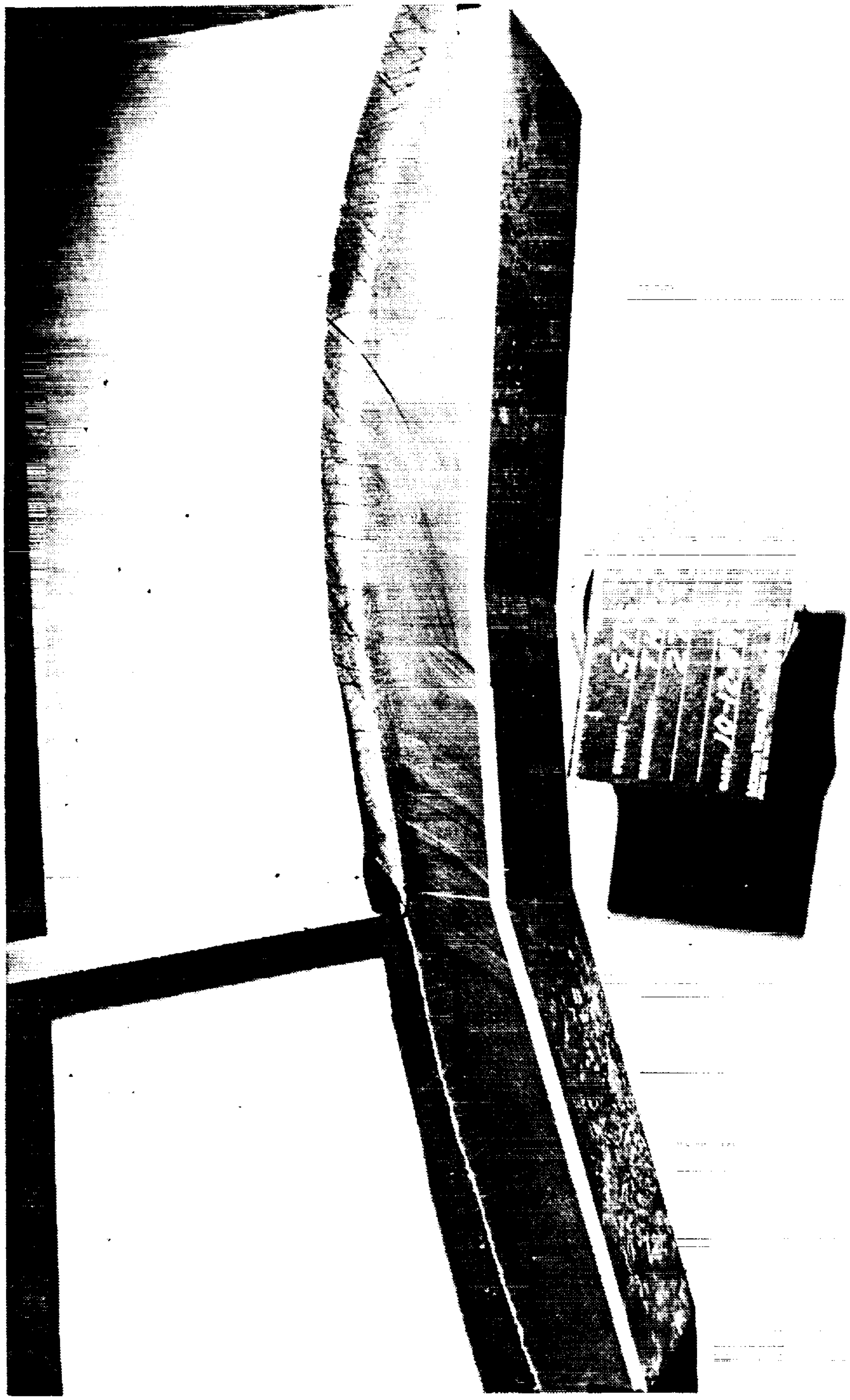

Figure 18 STS-28A Throat/Throat Inlet Section (270 deg)

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Table 3 STS-28A Throat Assembly Erosion and Char Data

Angular Location	Stations												
0 degrees	1	2	4	6	8	10	12	14	16	18	20	22	23
Measured Erosion	1.11	1.15	1.19	1.21	1.25	1.19	1.17	1.17	1.07	0.90	0.68	0.45	0.38
Measured Char	0.62	0.65	0.66	0.63	0.53	0.57	0.56	0.61	0.65	0.71	0.72	0.79	0.84
Adjusted Char *	0.47	0.49	0.50	0.47	0.40	0.43	0.42	0.46	0.49	0.53	0.54	0.59	0.63
2E + 1.25AC	2.80	2.91	3.00	3.01	3.00	2.91	2.87	2.91	2.75	2.47	2.04	1.64	1.55
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	2.231	2.583	2.110
Margin of Safety	0.13	0.12	0.11	0.09	0.06	0.17	0.23	0.25	0.35	0.45	0.10	0.57	0.36
90 degrees													
Measured Erosion	1.08	1.09	1.15	1.19	1.32	1.15	1.13	1.09	1.05	0.87	0.68	0.44	0.41
Measured Char	0.64	0.71	0.70	0.63	0.49	0.58	0.55	0.54	0.53	0.60	0.70	0.87	0.83
Adjusted Char *	0.48	0.53	0.53	0.47	0.37	0.44	0.41	0.41	0.40	0.45	0.53	0.65	0.62
2E + 1.25AC	2.76	2.85	2.96	2.97	3.10	2.84	2.78	2.69	2.60	2.30	2.02	1.70	1.60
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	2.231	2.583	2.110
Margin of Safety	0.15	0.14	0.12	0.10	0.03	0.19	0.27	0.35	0.43	0.56	0.11	0.52	0.32
180 degrees													
Measured Erosion	NA	NA	NA	NA	1.31	1.16	1.13	1.11	1.04	0.88	0.67	0.42	0.37
Measured Char	NA	NA	NA	NA	0.47	0.59	0.53	0.54	0.53	0.61	0.68	0.80	0.84
Adjusted Char *	NA	NA	NA	NA	0.35	0.44	0.40	0.41	0.40	0.46	0.51	0.60	0.63
2E + 1.25AC	NA	NA	NA	NA	3.06	2.87	2.76	2.73	2.58	2.33	1.98	1.59	1.53
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	3.231	2.583	2.110
Margin of Safety	NA	NA	NA	NA	0.04	0.18	0.28	0.33	0.44	0.54	0.63	0.62	0.38
270 degrees													
Measured Erosion	1.10	1.09	1.13	1.18	1.24	1.20	1.17	1.12	1.05	0.89	0.68	0.42	0.36
Measured Char	0.59	0.63	0.63	0.62	0.54	0.62	0.54	0.59	0.61	0.69	0.75	0.84	0.85
Adjusted Char *	0.44	0.47	0.47	0.47	0.41	0.47	0.41	0.44	0.46	0.52	0.56	0.63	0.64
2E + 1.25AC	2.75	2.77	2.85	2.94	2.99	2.98	2.85	2.79	2.67	2.43	2.06	1.63	1.52
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	3.231	2.583	2.110
Margin of Safety	0.15	0.17	0.16	0.12	0.07	0.14	0.24	0.30	0.39	0.48	0.57	0.59	0.39

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

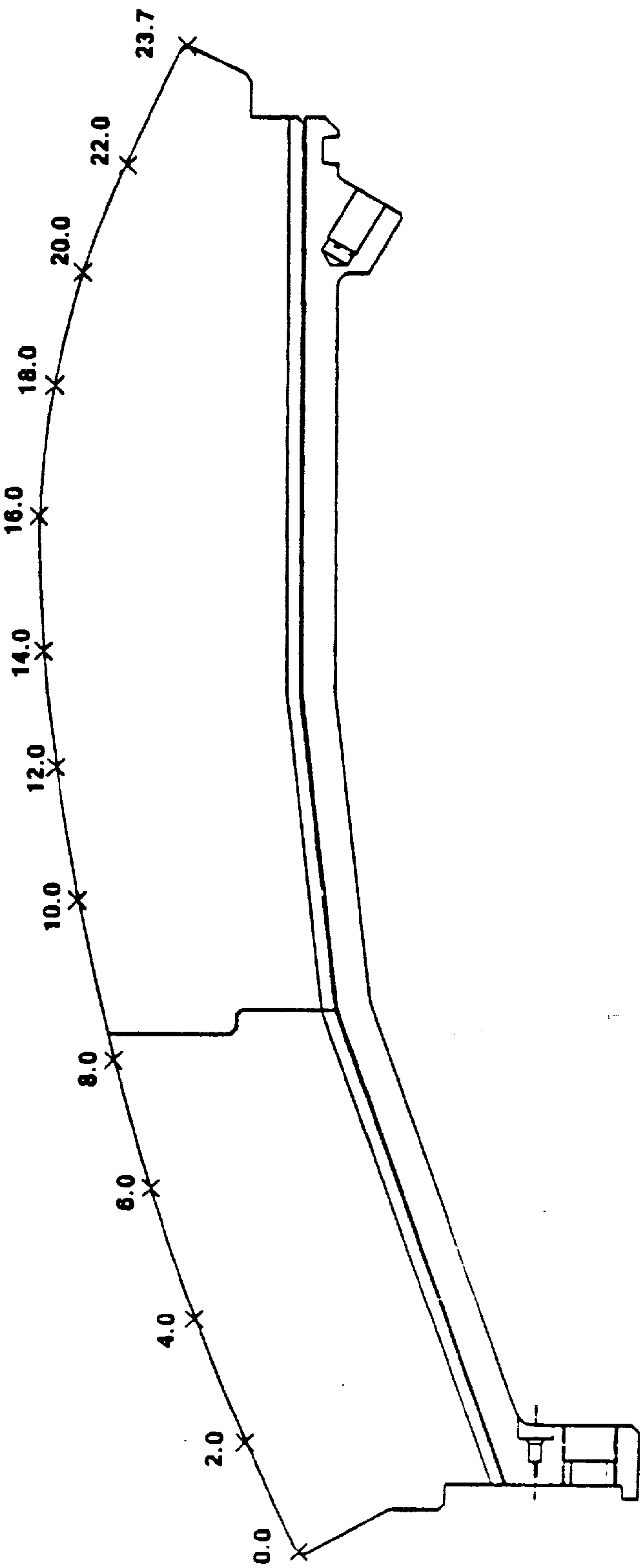
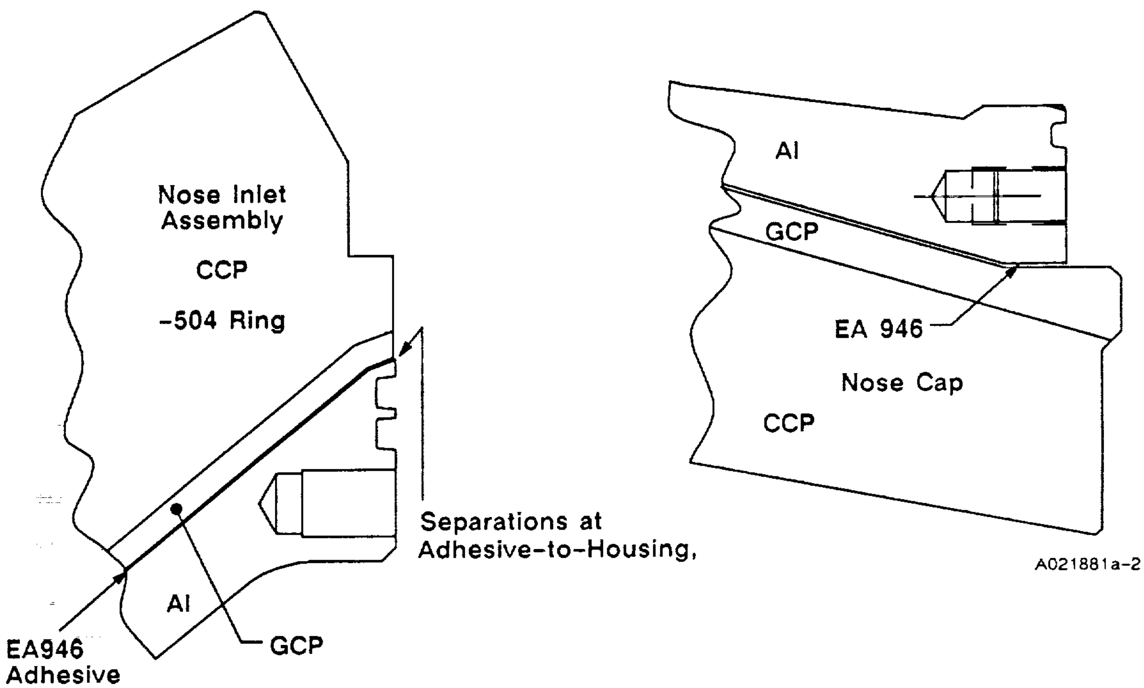


Figure 19 STS-28A Throat Inlet Assembly Erosion Measurement Stations



Metal-to-Adhesive
Bondline Separations

Location (deg)	Radial Separation (in.)
0-75	0.010
165-180	0.010
270-0	0.010

Figure 20 STS-28A Nose Inlet Assy Bondline Separations

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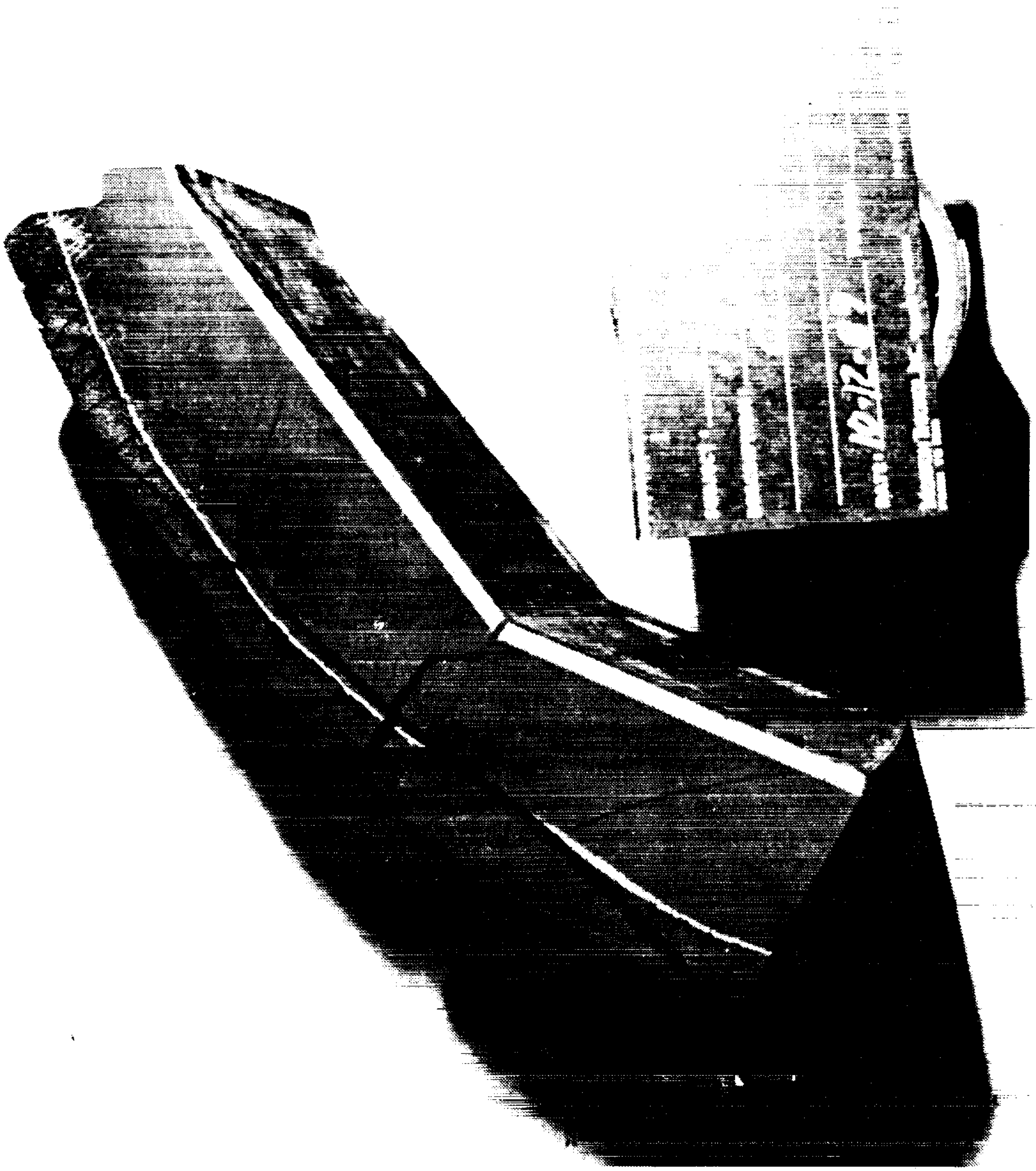

Figure 21 STS-28A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (0 deg)

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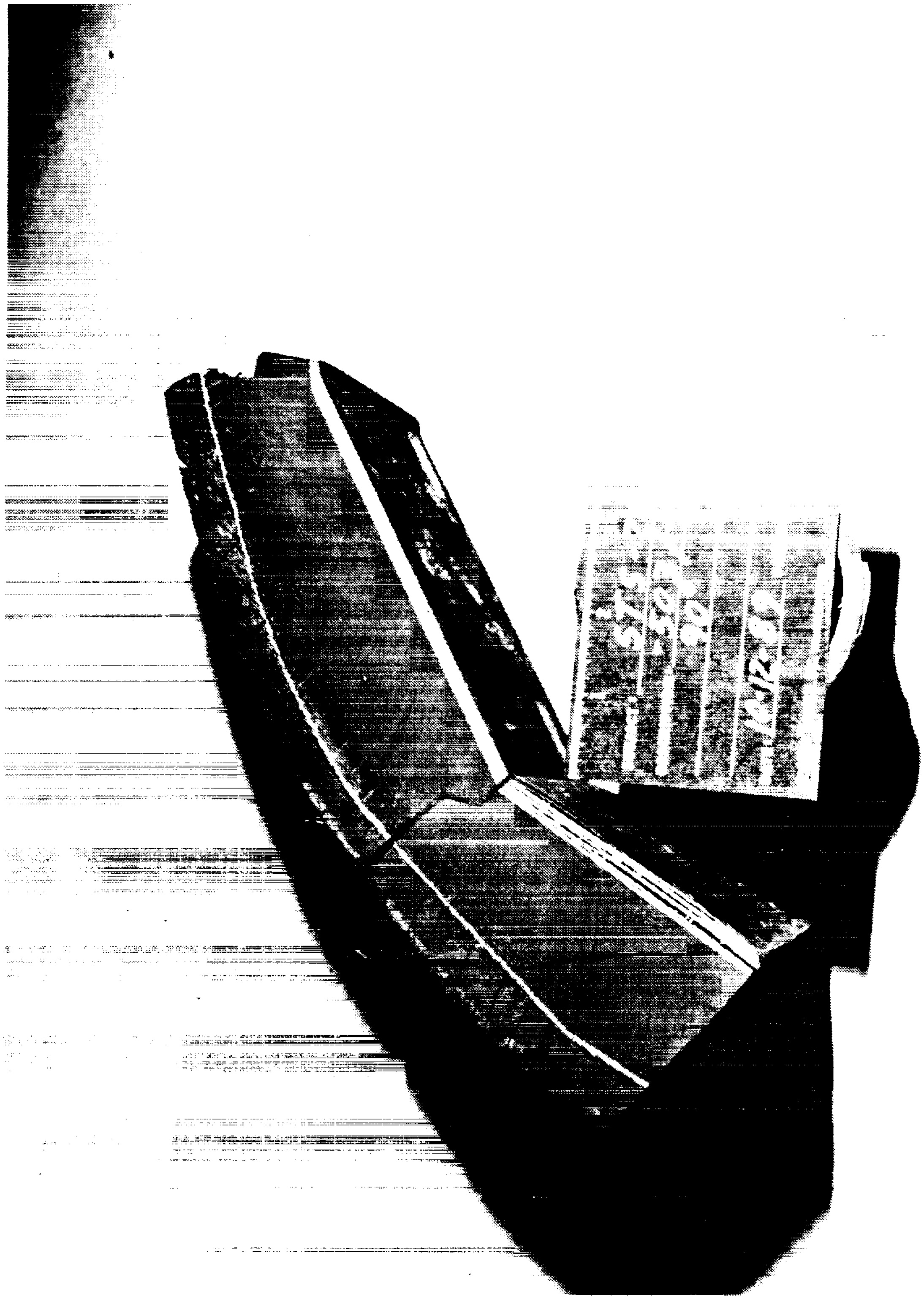

Figure 22 STS-28A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (90 deg)

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Figure 23 STS-28A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (180 deg)

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Figure 24 STS-28A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (270 deg)

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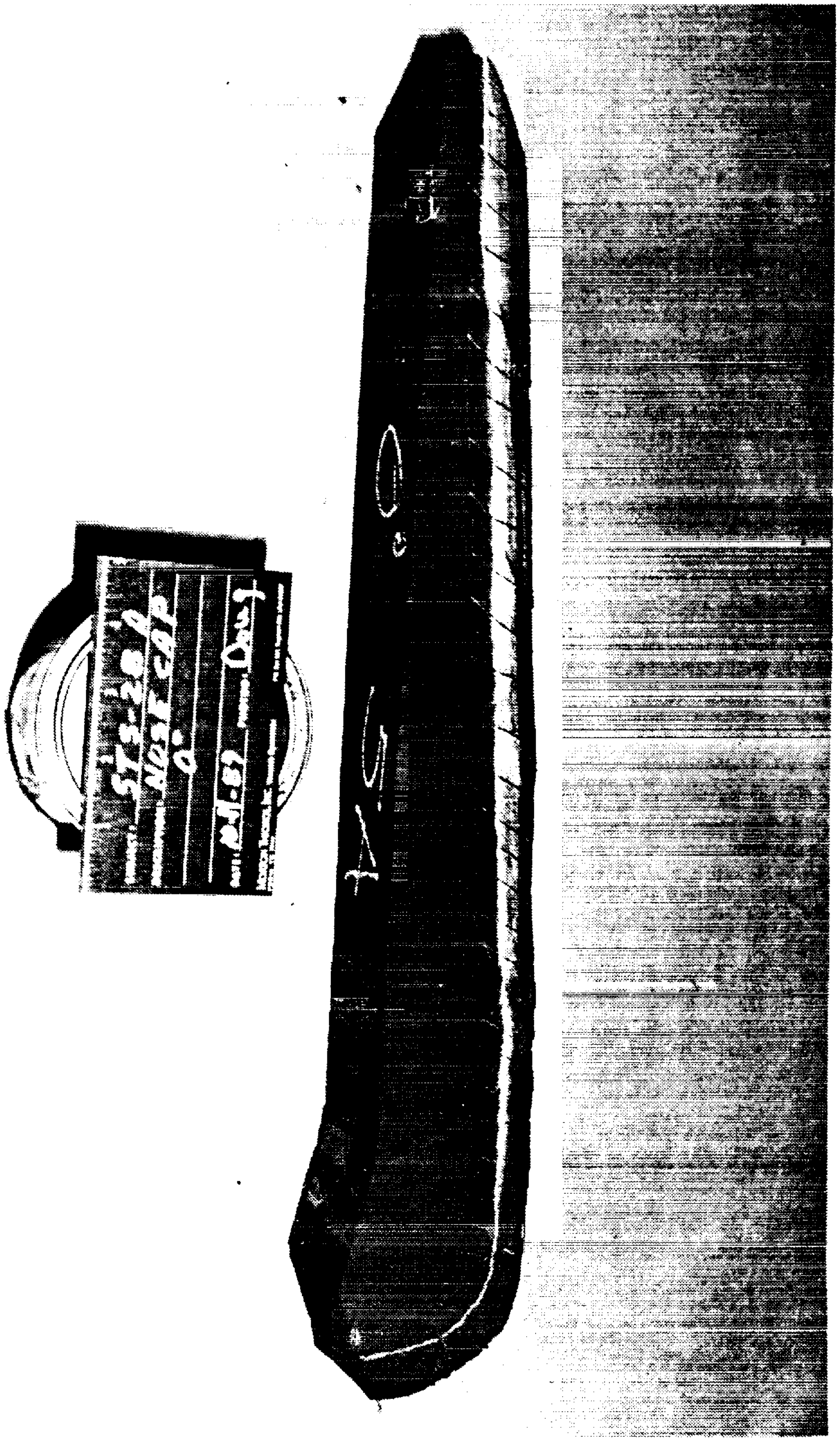

Figure 25 STS-28A Nose Cap Section (0 deg)

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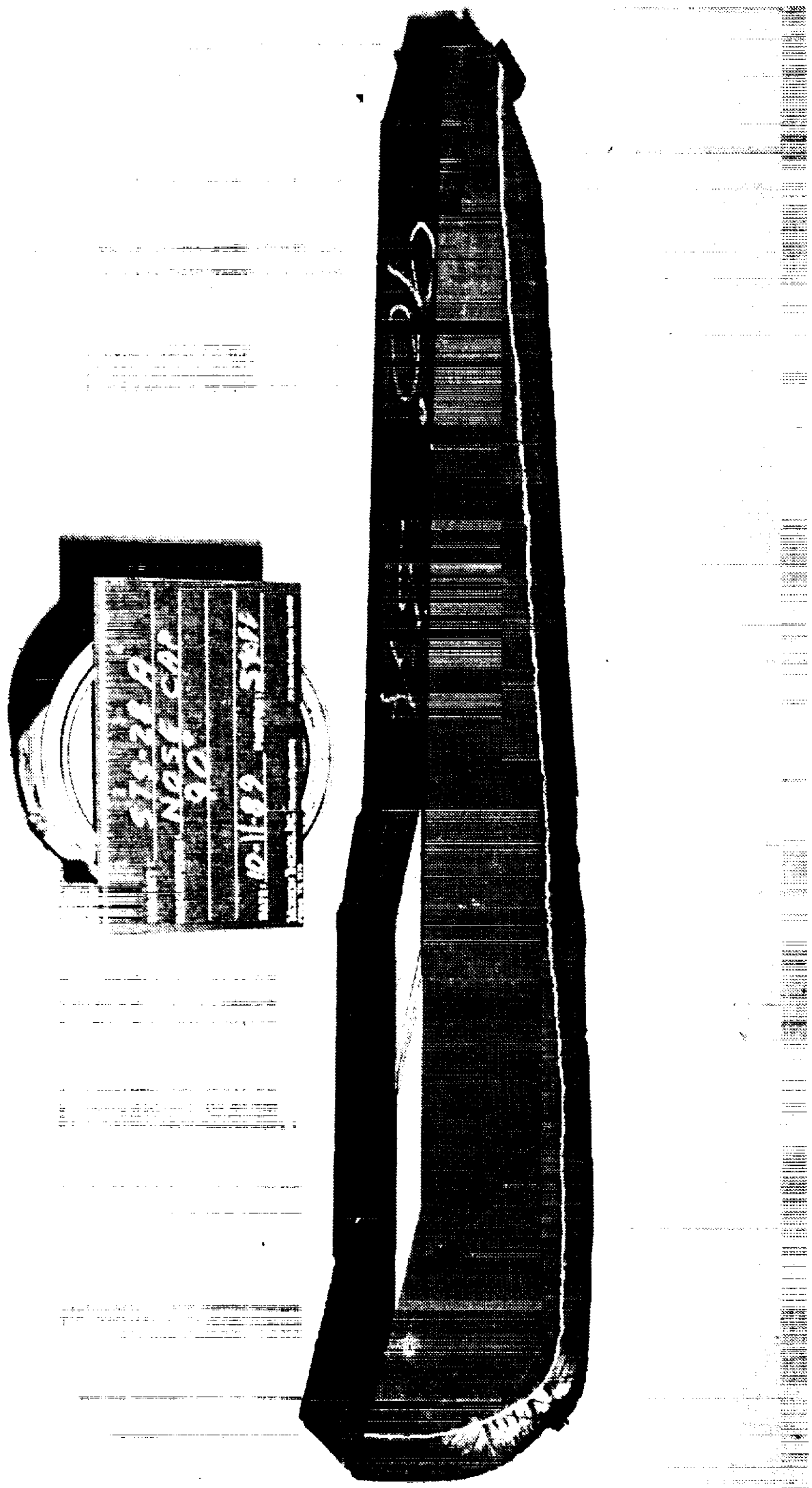

Figure 26 STS-28A Nose Cap Section (90 deg)

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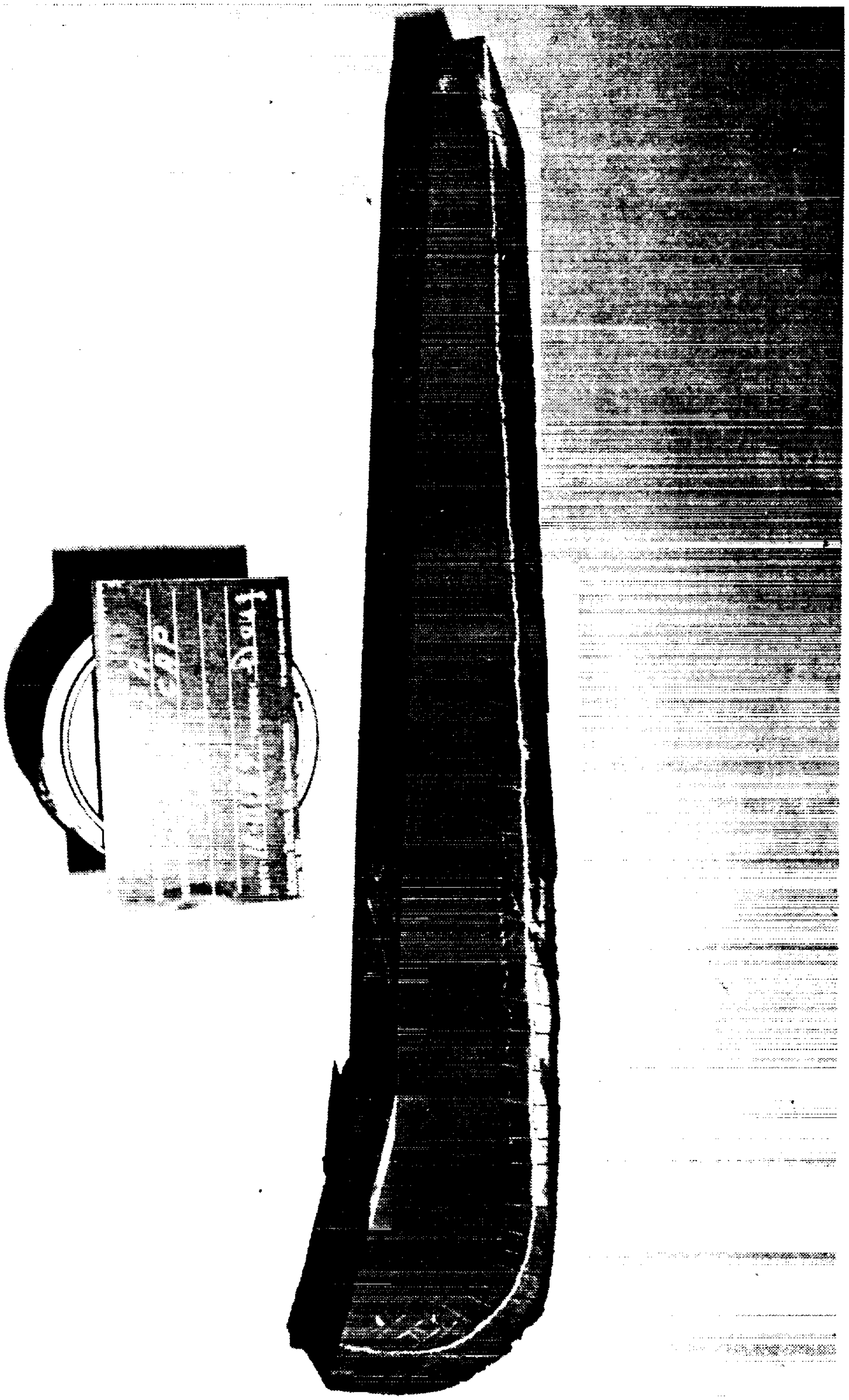

Figure 27 STS-28A Nose Cap Section (180 deg)

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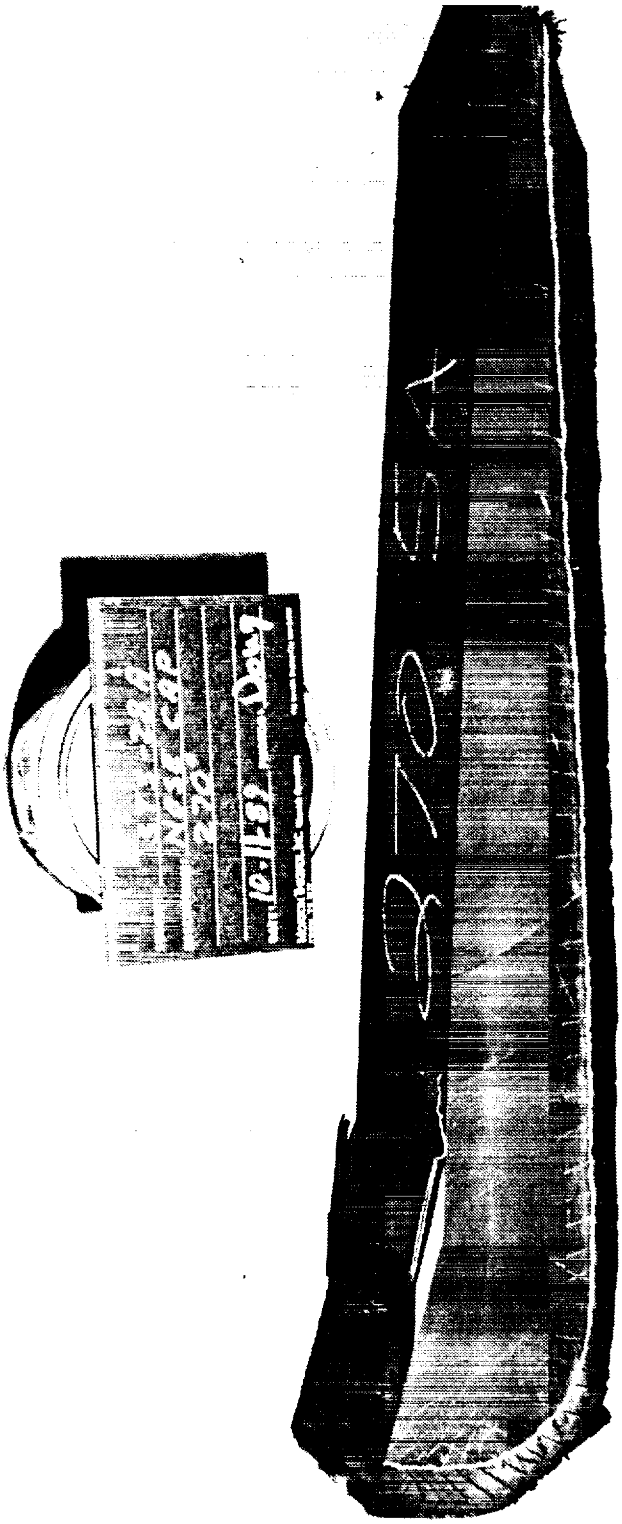

Figure 28 STS-28A Nose Cap Section (270 deg)

Table 4 STS-28A Nose Inlet Rings (-503, -504) Erosion and Char Data

Angular Location	Stations						
	28	30	32	34	36	38	39
0 degrees							
Measured Erosion	1.16	0.86	0.86	0.82	0.82	0.93	0.96
Measured Char	0.71	0.83	0.64	0.50	0.59	0.61	0.63
Adjusted Char*	0.53	0.62	0.48	0.38	0.44	0.46	0.47
2E + 1.25AC	2.99	2.50	2.32	2.11	2.19	2.43	2.51
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.17	0.30	0.27	0.51	0.46	0.24	0.19
90 degrees							
Measured Erosion	1.02	0.81	0.89	0.84	0.83	0.93	0.96
Measured Char	0.75	0.76	0.61	0.51	0.57	0.61	0.59
Adjusted Char*	0.56	0.57	0.46	0.38	0.43	0.46	0.44
2E + 1.25AC	2.74	2.33	2.35	2.16	2.19	2.43	2.47
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.28	0.39	0.25	0.47	0.46	0.24	0.21
180 degrees							
Measured Erosion	1.01	0.80	0.90	0.80	0.80	0.87	0.93
Measured Char	0.70	0.71	0.63	0.59	0.62	0.63	0.63
Adjusted Char*	0.53	0.53	0.47	0.44	0.47	0.47	0.47
2E + 1.25AC	2.68	2.27	2.39	2.15	2.18	2.33	2.45
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.31	0.44	0.23	0.48	0.47	0.30	0.22
270 degrees							
Measured Erosion	1.13	0.96	0.98	0.87	0.88	0.92	0.96
Measured Char	0.73	0.68	0.64	0.51	0.59	0.61	0.65
Adjusted Char*	0.55	0.51	0.48	0.38	0.44	0.46	0.49
2E + 1.25AC	2.94	2.56	2.56	2.22	2.31	2.41	2.53
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.19	0.27	0.15	0.43	0.38	0.25	0.19

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \text{ X erosion} + 1.25 \text{ X adj char*}} - 1$$

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Table 5 STS-28A Nose Cap Assembly Erosion and Char Data

Angular Location	Stations 1.5	4	6	8	10	12	14	16	18	20	22	24	26
0 degrees													
Measured Erosion	NA	0.38	0.42	0.46	0.52	0.55	0.70	0.75	0.88	1.09	1.71	1.90	1.37
Measured Char	NA	0.67	0.62	0.67	0.63	0.66	0.56	0.50	0.54	0.53	0.68	0.77	0.74
Adjusted Char *	NA	0.54	0.50	0.54	0.50	0.53	0.45	0.40	0.43	0.42	0.54	0.62	0.56
2E + 1.25AC	NA	1.43	1.46	1.59	1.67	1.76	1.96	2.00	2.30	2.71	4.10	4.57	3.43
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.43	0.54	0.55	0.60	0.64	0.58	0.65	0.52	0.50	0.15	0.03	0.13
45 degrees													
Measured Erosion	NA	0.37	0.36	0.45	0.50	0.53	0.66	0.68	0.84	1.09	1.64	1.84	1.31
Measured Char	NA	0.70	0.66	0.60	0.51	0.51	0.45	0.50	0.47	0.49	0.66	0.74	0.75
Adjusted Char *	NA	0.56	0.53	0.48	0.41	0.41	0.36	0.40	0.38	0.39	0.53	0.59	0.56
2E + 1.25AC	NA	1.44	1.38	1.50	1.51	1.57	1.77	1.86	2.15	2.67	3.94	4.42	3.32
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.42	0.63	0.64	0.77	0.83	0.74	0.77	0.63	0.52	0.20	0.06	0.16
90 degrees													
Measured Erosion	NA	0.31	0.34	0.39	0.41	0.46	0.50	0.61	0.68	0.88	1.36	1.59	1.17
Measured Char	NA	0.63	0.59	0.55	0.56	0.53	0.59	0.46	0.50	0.51	0.69	0.82	0.77
Adjusted Char *	NA	0.50	0.47	0.44	0.45	0.42	0.47	0.37	0.40	0.41	0.55	0.66	0.58
2E + 1.25AC	NA	1.25	1.27	1.33	1.38	1.45	1.59	1.68	1.86	2.27	3.41	4.00	3.06
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.63	0.77	0.85	0.93	0.98	0.94	0.96	0.89	0.79	0.38	0.17	0.26
135 degrees													
Measured Erosion	NA	0.35	0.39	0.44	0.44	0.50	0.56	0.64	0.74	1.01	1.46	1.61	1.15
Measured Char	NA	0.63	0.64	0.60	0.63	0.61	0.52	0.43	0.56	0.53	0.71	0.67	0.65
Adjusted Char *	NA	0.50	0.51	0.48	0.50	0.49	0.42	0.34	0.45	0.42	0.57	0.54	0.49
2E + 1.25AC	NA	1.33	1.42	1.48	1.51	1.61	1.64	1.71	2.04	2.55	3.63	3.89	2.91
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.53	0.58	0.66	0.77	0.79	0.88	0.93	0.72	0.59	0.30	0.21	0.33

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

REVISION

Table 5 STS-28A Nose Cap Assembly Erosion and Char Data (Cont)

Angular Location	Stations												
	1.5	4	6	8	10	12	14	16	18	20	22	24	26
180 degrees													
Measured Erosion	NA	0.35	0.36	0.42	0.46	0.52	0.57	0.62	0.72	0.97	1.41	1.59	1.10
Measured Char	NA	0.55	0.58	0.52	0.49	0.46	0.47	0.51	0.50	0.42	0.66	0.67	0.73
Adjusted Char *	NA	0.44	0.46	0.42	0.39	0.37	0.38	0.41	0.40	0.34	0.53	0.54	0.55
2E + 1.25AC	NA	1.25	1.30	1.36	1.41	1.50	1.61	1.75	1.94	2.36	3.48	3.85	2.88
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.63	0.73	0.81	0.89	0.92	0.92	0.88	0.81	0.72	0.35	0.22	0.34
225 degrees													
Measured Erosion	NA	0.37	0.40	0.44	0.45	0.53	0.58	0.68	0.78	0.95	1.45	1.72	1.22
Measured Char	NA	0.54	0.53	0.54	0.52	0.53	0.49	0.45	0.43	0.49	0.76	0.75	0.74
Adjusted Char *	NA	0.43	0.42	0.43	0.42	0.42	0.39	0.36	0.34	0.39	0.61	0.60	0.56
2E + 1.25AC	NA	1.28	1.33	1.42	1.42	1.59	1.65	1.81	1.99	2.39	3.66	4.19	3.13
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.59	0.69	0.73	0.88	0.81	0.87	0.82	0.76	0.70	0.29	0.12	0.23
270 degrees													
Measured Erosion	NA	0.35	0.42	0.48	0.46	0.50	0.56	0.67	0.73	0.98	1.52	1.75	1.27
Measured Char	NA	0.56	0.55	0.51	0.49	0.47	0.47	0.40	0.43	0.45	0.73	0.77	0.81
Adjusted Char *	NA	0.45	0.44	0.41	0.39	0.38	0.38	0.32	0.34	0.36	0.58	0.62	0.61
2E + 1.25AC	NA	1.26	1.39	1.47	1.41	1.47	1.59	1.74	1.89	2.41	3.77	4.27	3.30
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.62	0.62	0.67	0.89	0.96	0.94	0.90	0.86	0.68	0.25	0.10	0.17
315 degrees													
Measured Erosion	NA	0.37	0.46	0.48	0.50	0.54	0.60	0.73	0.85	1.08	1.62	1.75	1.20
Measured Char	NA	0.62	0.53	0.51	0.51	0.52	0.60	0.46	0.47	0.52	0.78	0.79	0.78
Adjusted Char *	NA	0.50	0.42	0.41	0.41	0.42	0.48	0.37	0.38	0.42	0.62	0.63	0.59
2E + 1.25AC	NA	1.36	1.45	1.47	1.51	1.60	1.80	1.92	2.17	2.68	4.02	4.29	3.13
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.50	0.55	0.67	0.77	0.80	0.72	0.72	0.62	0.51	0.17	0.09	0.23

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

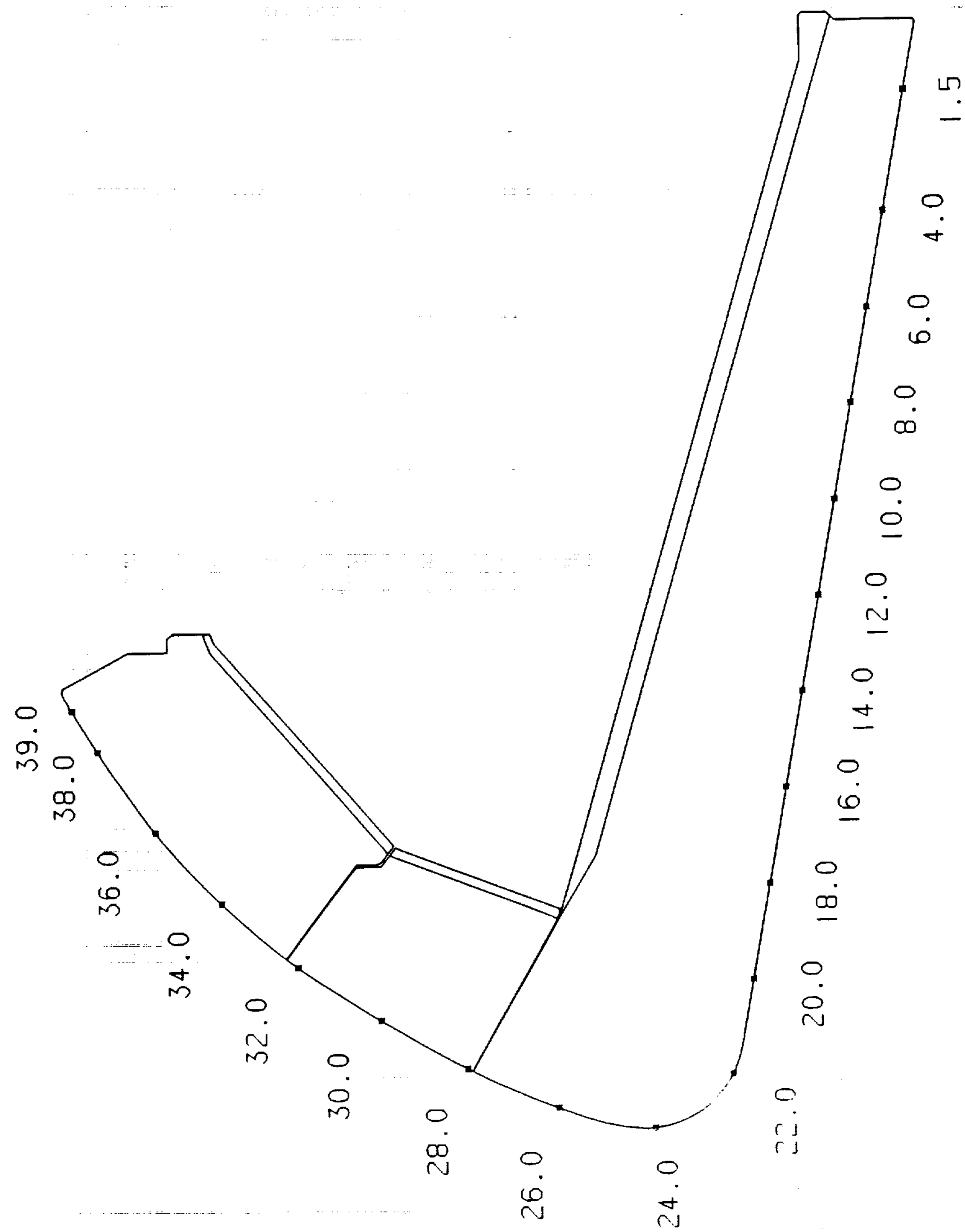

Figure 29 STS-28A Nose Inlet Assy Erosion Measurement Stations

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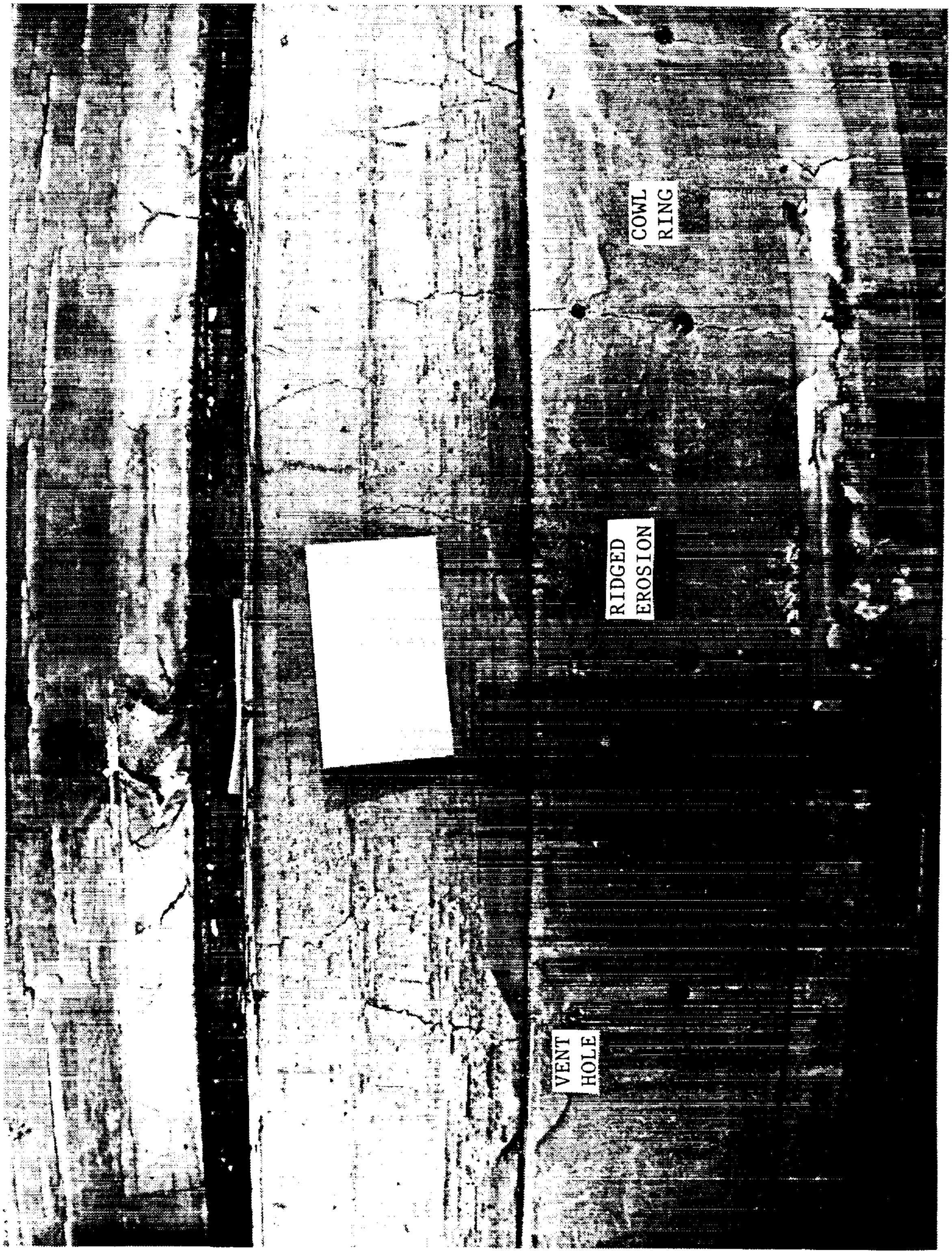

Figure 30 STS-28A Cowl/OBR Closeup (0 deg)

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Figure 31 STS-28A Cowl/OBR Closeup (90 deg)

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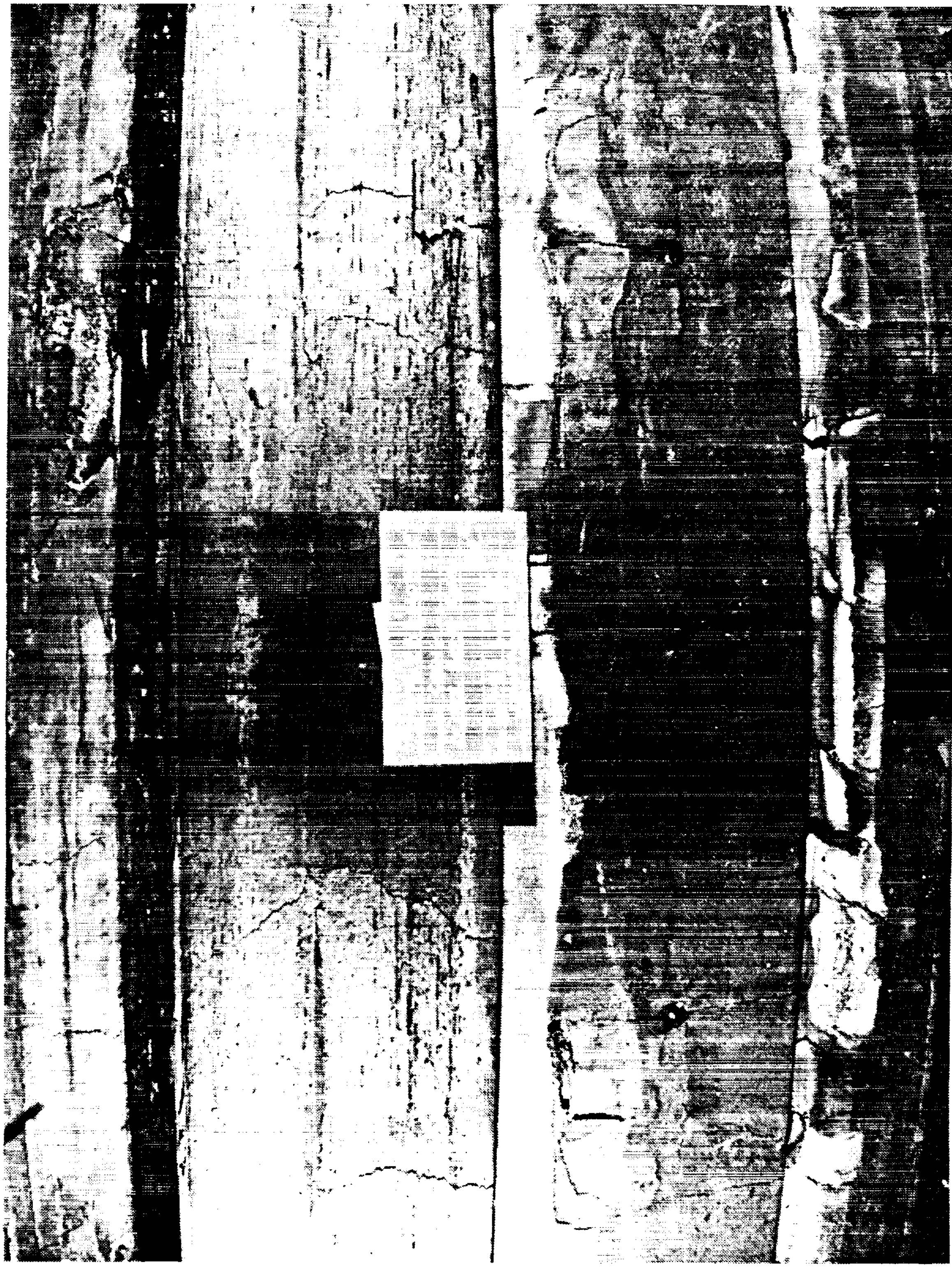

Figure 32 STS-28A Cowl/OBR Closeup (180 deg)

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Figure 33 STS-28A Cowl/OBR Closeup (270 deg)

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Figure 34 STS-28A Cowl Ring Section (0 deg)

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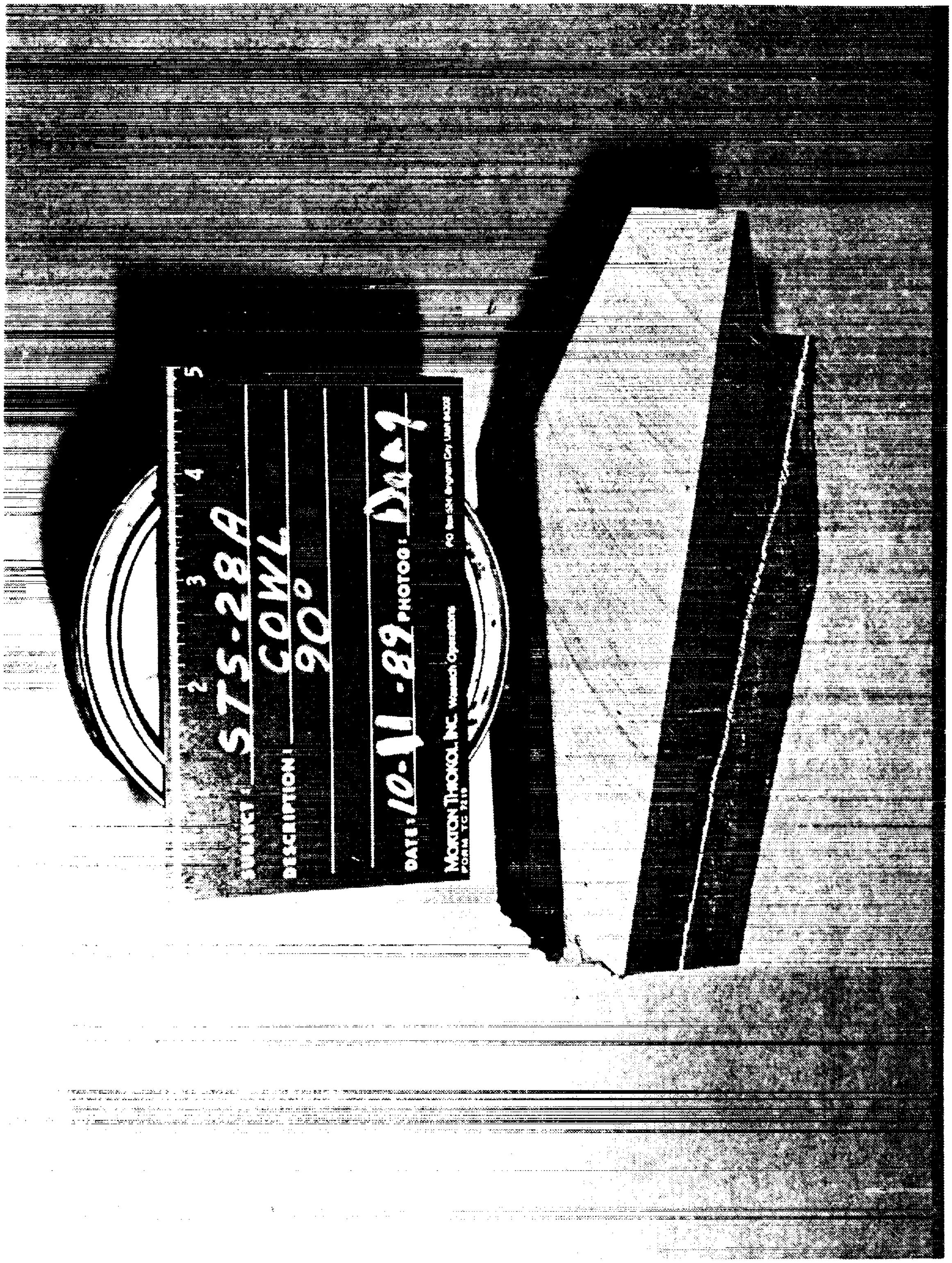

Figure 35 STS-28A Cowl Ring Section (90 deg)

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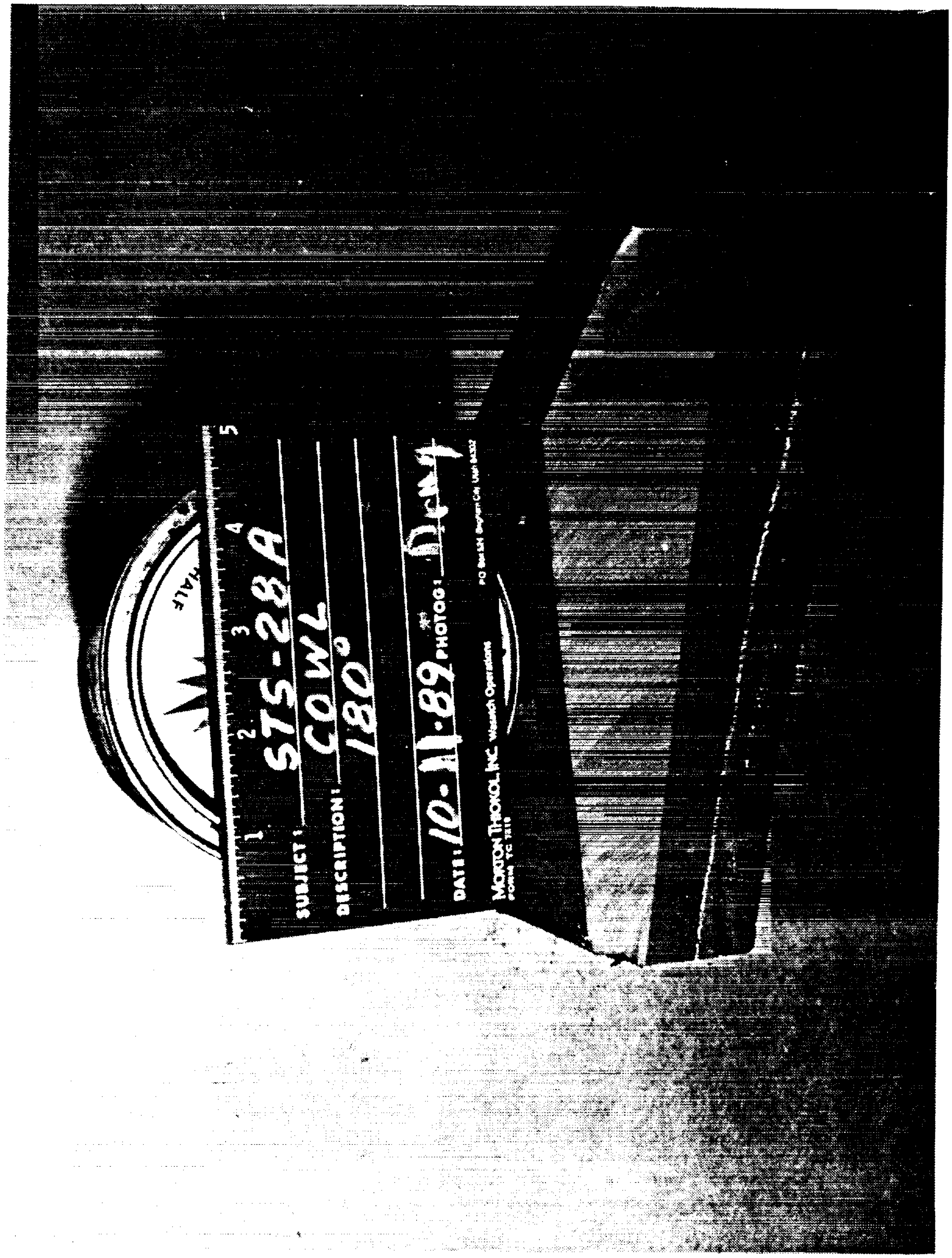

Figure 36 STS-28A Cowl Ring Section (180 deg)

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Figure 37 STS-28A Cowl Ring Section (270 deg)

Table 6 STS-28A Cowl/OBR Erosion and Char Data

Angular Location	Stations											
0 degrees	0	1	2	3	4	5	6	7	8	9	10	11.3
Measured Erosion	NA	0.24	0.30	0.34	0.34	0.33	0.30	0.34	NA	NA	0.05	0.09
Measured Char	NA	0.67	0.66	0.63	0.64	0.68	0.70	0.59	NA	NA	0.86	0.93
Adjusted Char *	NA	0.54	0.53	0.50	0.51	0.54	0.56	0.47	NA	NA	0.69	0.74
2E + 1.25AC	NA	1.15	1.26	1.31	1.32	1.34	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.29	1.22	NA	NA	1.11	1.25
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.30	0.25	0.26	0.31	0.35	0.46	0.61	NA	NA	0.52	0.36
45 degrees												
Measured Erosion	NA	0.21	0.30	0.32	0.36	NA	NA	NA	NA	NA	0.04	0.12
Measured Char	NA	0.67	0.55	0.59	0.55	NA	NA	NA	NA	NA	0.87	0.91
Adjusted Char *	NA	0.54	0.44	0.47	0.44	NA	NA	NA	NA	NA	0.70	0.73
2E + 1.25AC	NA	1.09	1.15	1.23	1.27	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.10	1.27
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.38	0.37	0.35	0.36	NA	NA	NA	NA	NA	0.53	0.34
90 degrees												
Measured Erosion	0.16	0.20	0.24	0.23	0.24	NA	NA	NA	NA	0.03	0.04	0.05
Measured Char	0.67	0.69	0.68	0.68	0.70	NA	NA	NA	NA	0.84	0.84	0.88
Adjusted Char *	0.54	0.55	0.54	0.54	0.56	NA	NA	NA	NA	0.67	0.67	0.70
2E + 1.25AC	0.99	1.09	1.16	1.14	1.18	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	1.05	1.07	1.13
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.42	0.38	0.36	0.45	0.47	NA	NA	NA	NA	0.59	0.58	0.51
135 degrees												
Measured Erosion	NA	0.27	0.30	0.29	0.25	0.16	0.11	0.07	NA	0.04	0.03	0.07
Measured Char	NA	0.60	0.59	0.64	0.68	0.75	0.77	0.90	NA	0.82	0.85	0.83
Adjusted Char *	NA	0.48	0.47	0.51	0.54	0.60	0.62	0.72	NA	0.66	0.68	0.66
2E + 1.25AC	NA	1.14	1.19	1.22	1.18	1.07	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.09	1.19	NA	1.04	1.07	1.10
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.31	0.33	0.36	0.47	0.69	0.73	0.65	NA	0.60	0.58	0.55

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1 \qquad \text{(Stations 0 through 5)}$$

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{1.5 \times (\text{erosion} + \text{adj char*})} - 1 \qquad \text{(Stations 6 through 11.3)}$$

Table 6 STS-28A Cowl/OBR Erosion and Char Data (Cont)

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10	11.3
180 degrees												
Measured Erosion	0.19	0.23	0.27	0.29	0.27	NA	NA	NA	NA	NA	0.03	0.03
Measured Char	0.69	0.67	0.65	0.67	0.73	NA	NA	NA	NA	NA	0.87	0.94
Adjusted Char *	0.55	0.54	0.52	0.54	0.58	NA	NA	NA	NA	NA	0.70	0.75
2E + 1.25AC	1.07	1.13	1.19	1.25	1.27	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.09	1.17
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.32	0.33	0.33	0.32	0.36	NA	NA	NA	NA	NA	0.55	0.45
225 degrees												
Measured Erosion	0.21	0.23	0.27	0.30	0.33	0.31	0.30	0.30	NA	NA	0.03	0.02
Measured Char	0.57	0.63	0.65	0.63	0.60	0.60	0.64	0.73	NA	NA	0.82	0.80
Adjusted Char *	0.46	0.50	0.52	0.50	0.48	0.48	0.51	0.58	NA	NA	0.66	0.64
2E + 1.25AC	0.99	1.09	1.19	1.23	1.26	1.22	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.22	1.33	NA	NA	1.03	0.99
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.42	0.38	0.33	0.35	0.38	0.48	0.55	0.48	NA	NA	0.64	0.72
270 degrees												
Measured Erosion	NA	0.24	0.27	0.27	0.26	0.22	0.17	0.17	NA	0.06	0.09	0.03
Measured Char	NA	0.60	0.62	0.66	0.72	0.76	0.84	0.89	NA	0.86	0.78	0.87
Adjusted Char *	NA	0.48	0.50	0.53	0.58	0.61	0.67	0.71	NA	0.69	0.62	0.70
2E + 1.25AC	NA	1.08	1.16	1.20	1.24	1.20	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.26	1.32	NA	1.12	1.07	1.09
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.39	0.36	0.38	0.40	0.51	0.50	0.48	NA	0.49	0.58	0.56
315 degrees												
Measured Erosion	0.19	0.26	0.29	0.32	0.34	NA	NA	NA	NA	0.03	0.04	0.00
Measured Char	0.60	0.59	0.60	0.59	0.64	NA	NA	NA	NA	0.88	0.87	1.03
Adjusted Char *	0.48	0.47	0.48	0.47	0.51	NA	NA	NA	NA	0.70	0.70	0.82
2E + 1.25AC	0.98	1.11	1.18	1.23	1.32	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	1.10	1.10	1.24
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.44	0.35	0.34	0.35	0.31	NA	NA	NA	NA	0.52	0.53	0.38

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1 \qquad \text{(Stations 0 through 5)}$$

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{1.5 \times (\text{erosion} + \text{adj char*})} - 1 \qquad \text{(Stations 6 through 11.3)}$$

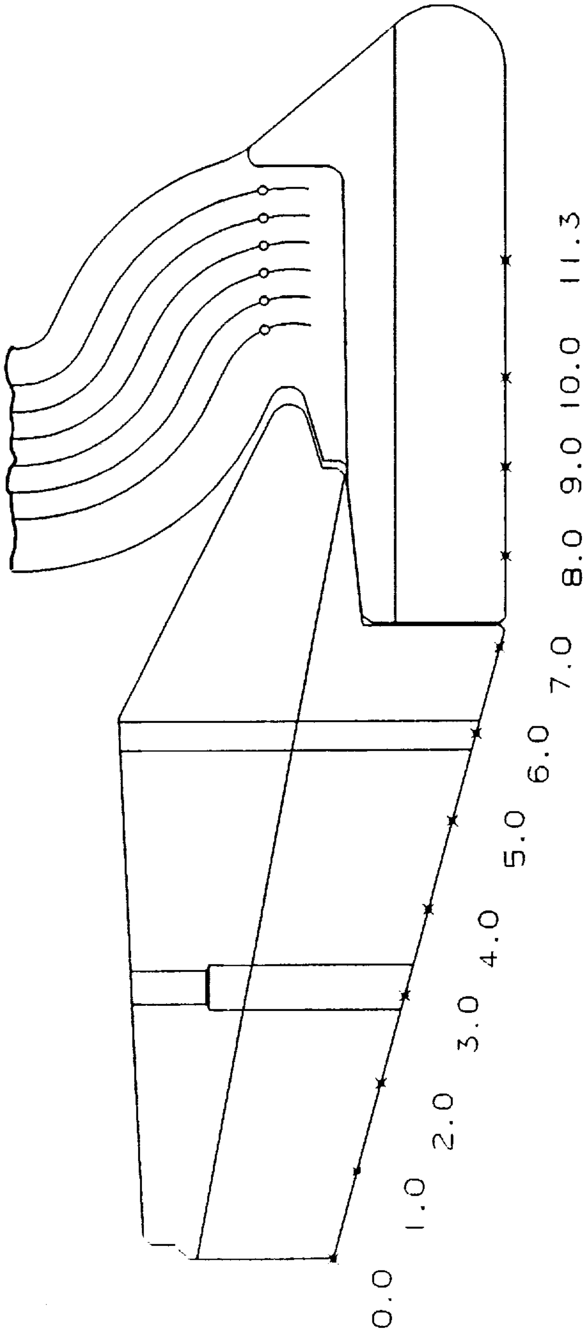

Figure 38 STS-28A Cowl Ring and Outer BOot Ring Erosion Measurement Stations

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Figure 39 STS-28A Outer Boot Ring Section (0 deg)

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Figure 40 STS-28A Outer Boot Ring Section (90 deg)

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Figure 41 STS-28A Outer Boot Ring Section (180 deg)

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Figure 42 STS-28A Outer Boot Ring Section (270 deg)

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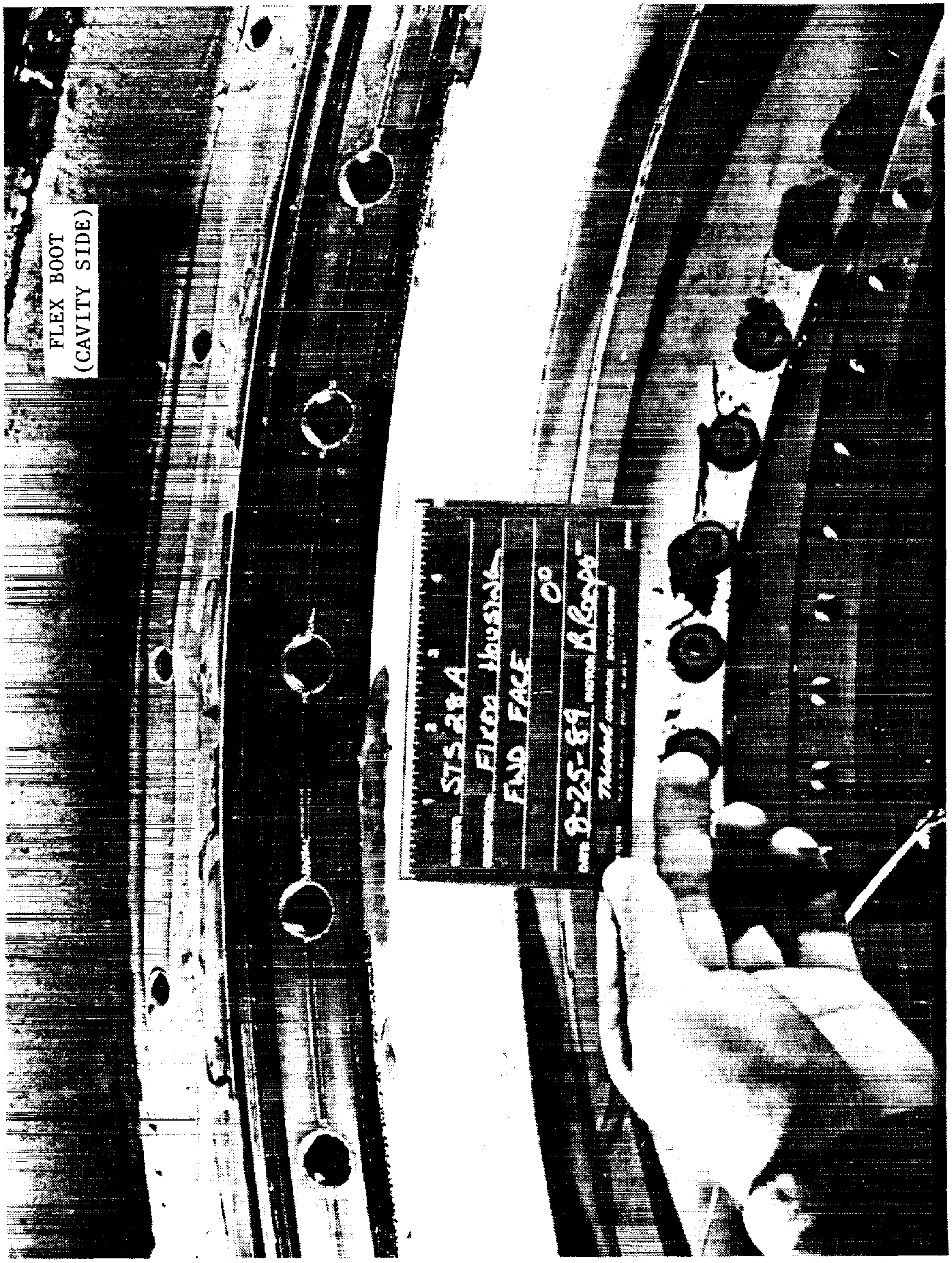

Figure 43 STS-28A Flex Boot (Cavity Side - 0 deg)

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Figure 44 STS-28A Flex Boot (Cavity Side - 90 deg)

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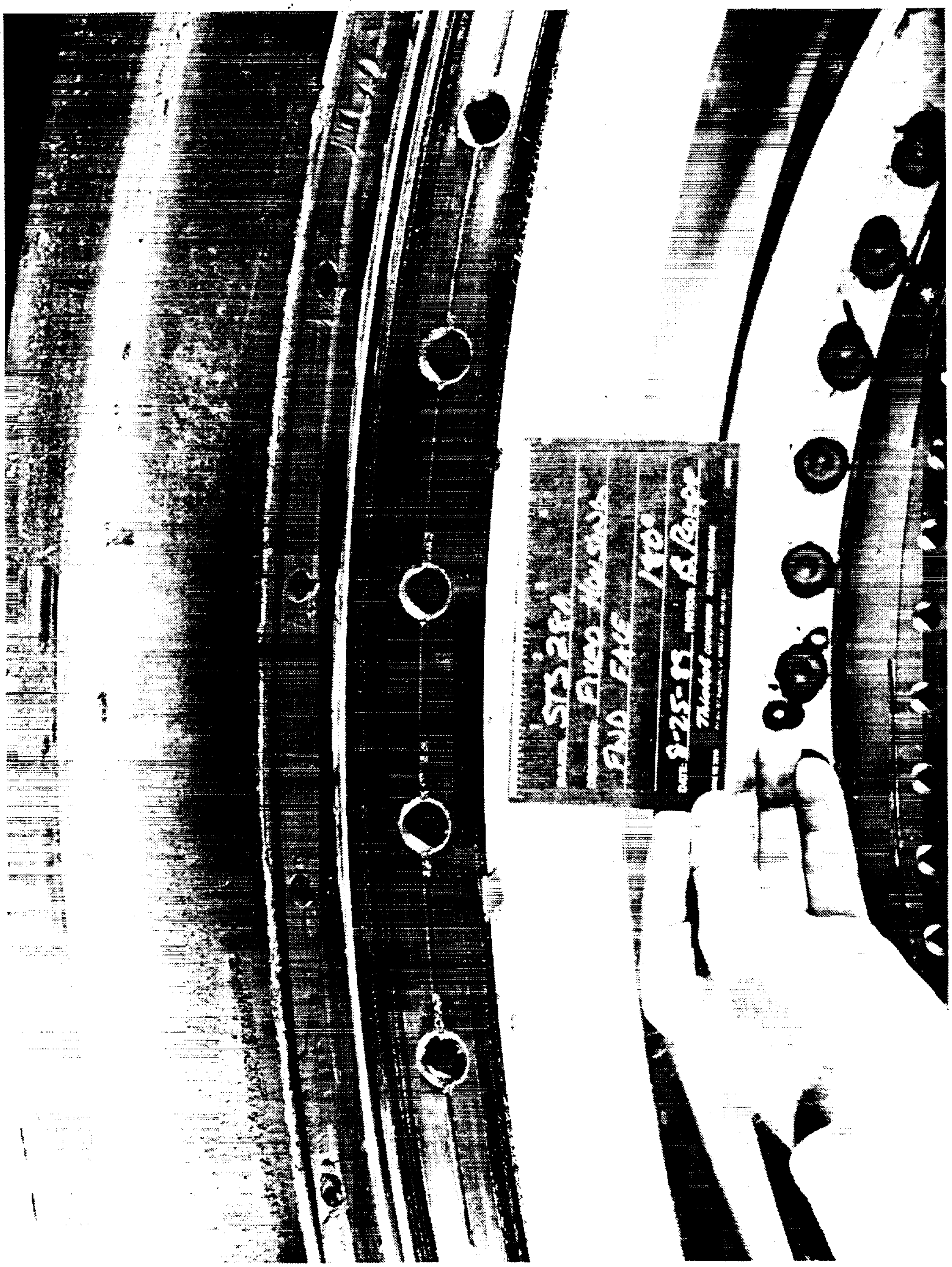

Figure 45 STS-28A Flex Boot (Cavity Side - 180 deg)

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Table 7 STS-28A Flex Boot Data Performance Margins of Safety

Degree Location	Remaining Plies	Max Material Affected Depth (in.)	Margin of Safety*
0	3 3/4	1.16	0.43
45	3 3/4	1.16	0.43
90	3 1/2	1.24	0.34
135	3 1/2	1.24	0.34
180	3 1/2	1.24	0.34
225	3 1/2	1.24	0.34
270	3 1/4	1.32	0.26
315	3 1/4	1.32	0.26

$$* \text{ PMS} = \frac{\text{minimum overall thickness}}{(1.5 \times \text{max material affected depth})} - 1$$

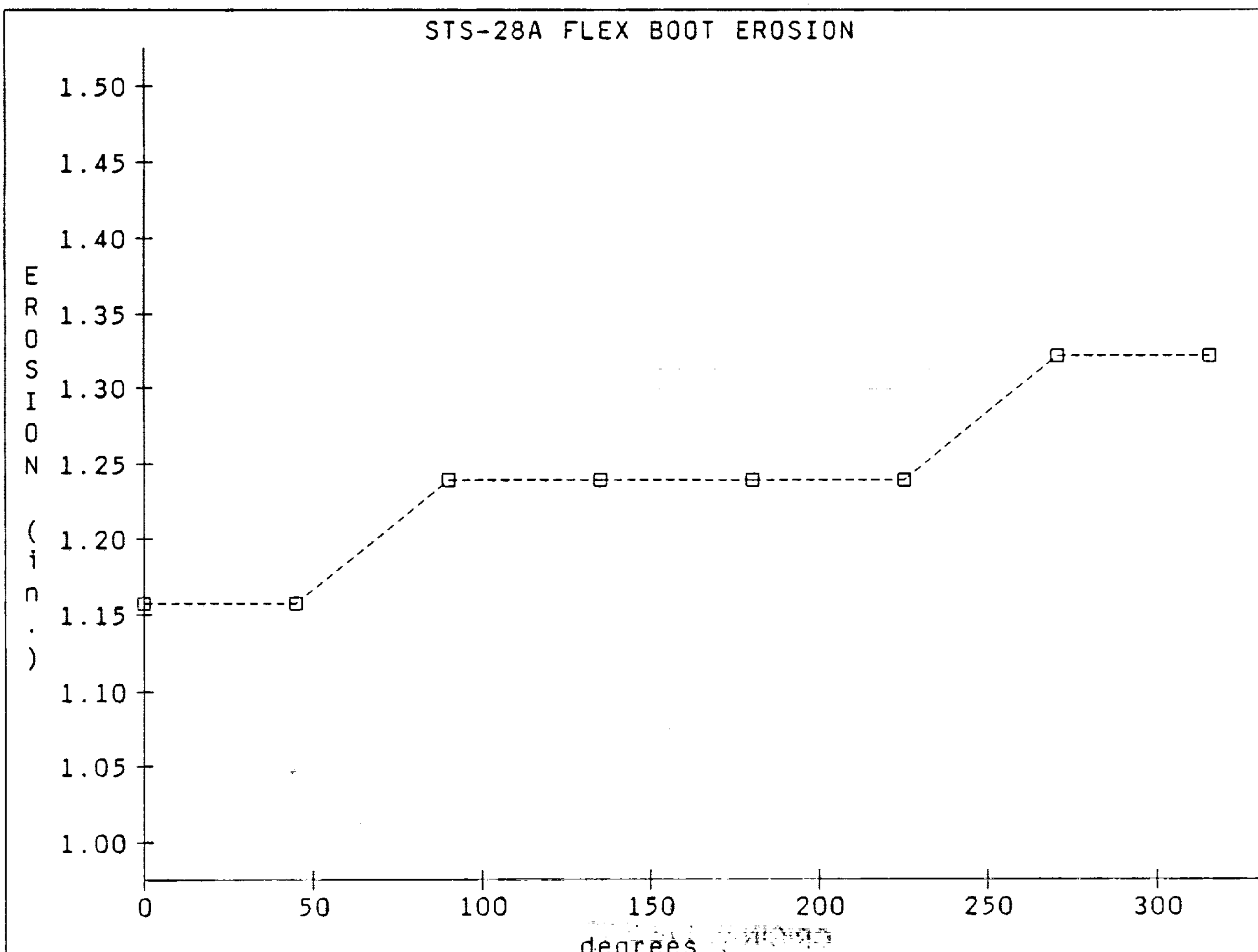

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Figure 46 STS-28A Fixed Housing Section (0 deg)

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Figure 47 STS-28A Fixed Housing Section (90 deg)

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Figure 48 STS-28A Fixed Housing Section (180 deg)

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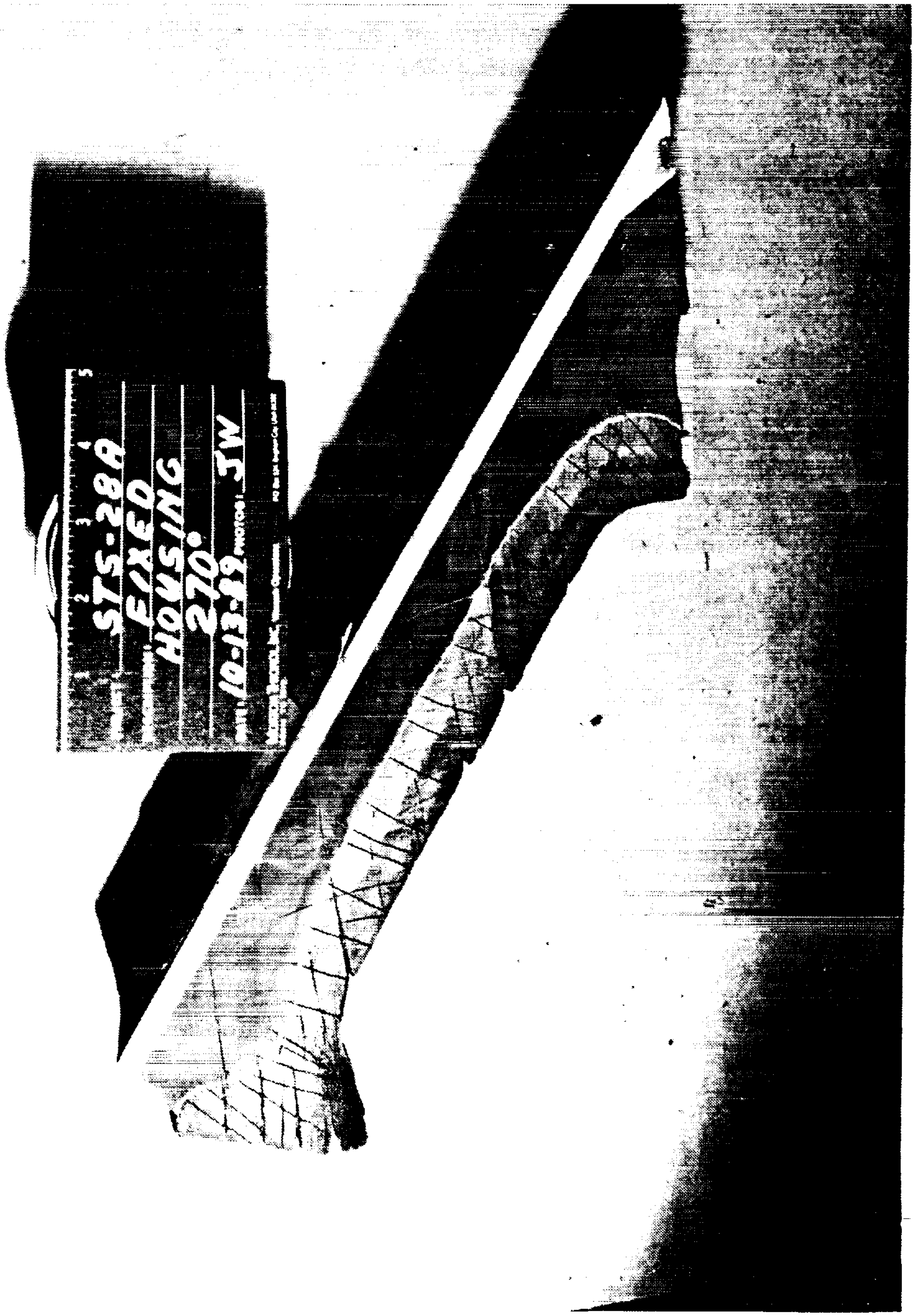

Figure 49 STS-28A Fixed Housing Section (270 deg)

Table 8 STS-28A Fixed Housing Insulation Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10.75
0 degrees											
Measured Erosion	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
Measured Char	1.14	1.11	1.14	1.13	1.07	1.05	1.03	0.96	0.83	NA	NA
Adjusted Char*	0.91	0.89	0.91	0.90	0.86	0.84	0.82	0.77	0.66	NA	NA
2E + 1.25AC	1.28	1.17	1.14	1.13	1.07	1.05	1.03	0.96	0.83	NA	NA
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.97	0.78	0.60	0.62	0.71	0.74	0.78	0.91	1.21	NA	NA
90 degrees											
Measured Erosion	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
Measured Char	1.22	1.21	1.19	1.20	1.19	1.12	1.13	1.08	0.98	1.02	NA
Adjusted Char*	0.98	0.97	0.95	0.96	0.95	0.90	0.90	0.86	0.78	0.82	NA
2E + 1.25AC	1.38	1.25	1.19	1.20	1.19	1.12	1.13	1.08	0.98	1.02	NA
RSRM min Liner Thickness	3.807	2.081	1.325	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.76	0.66	0.53	0.52	0.54	0.63	0.62	0.70	0.87	1.38	NA
180 degrees											
Measured Erosion	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Measured Char	1.24	1.15	1.01	0.98	0.98	0.97	1.00	0.93	0.87	0.94	1.76
Adjusted Char*	0.99	0.92	0.81	0.78	0.78	0.78	0.80	0.74	0.70	0.75	1.41
2E + 1.25AC	1.38	1.15	1.01	0.98	0.98	0.97	1.00	0.93	0.87	0.94	1.76
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.76	0.81	0.81	0.86	0.87	0.89	0.83	0.97	1.11	1.58	0.73
270 degrees											
Measured Erosion	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Measured Char	1.23	1.07	1.13	1.06	1.03	1.04	1.05	0.98	0.87	0.78	1.80
Adjusted Char*	0.98	0.86	0.90	0.85	0.82	0.83	0.84	0.78	0.70	0.62	1.44
2E + 1.25AC	1.31	1.15	1.13	1.06	1.03	1.04	1.05	0.98	0.87	0.78	1.80
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.91	0.81	0.62	0.72	0.78	0.76	0.74	0.87	1.11	2.11	0.69

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{Erosion} + 1.25 \times \text{Adj Char*}} - 1$$

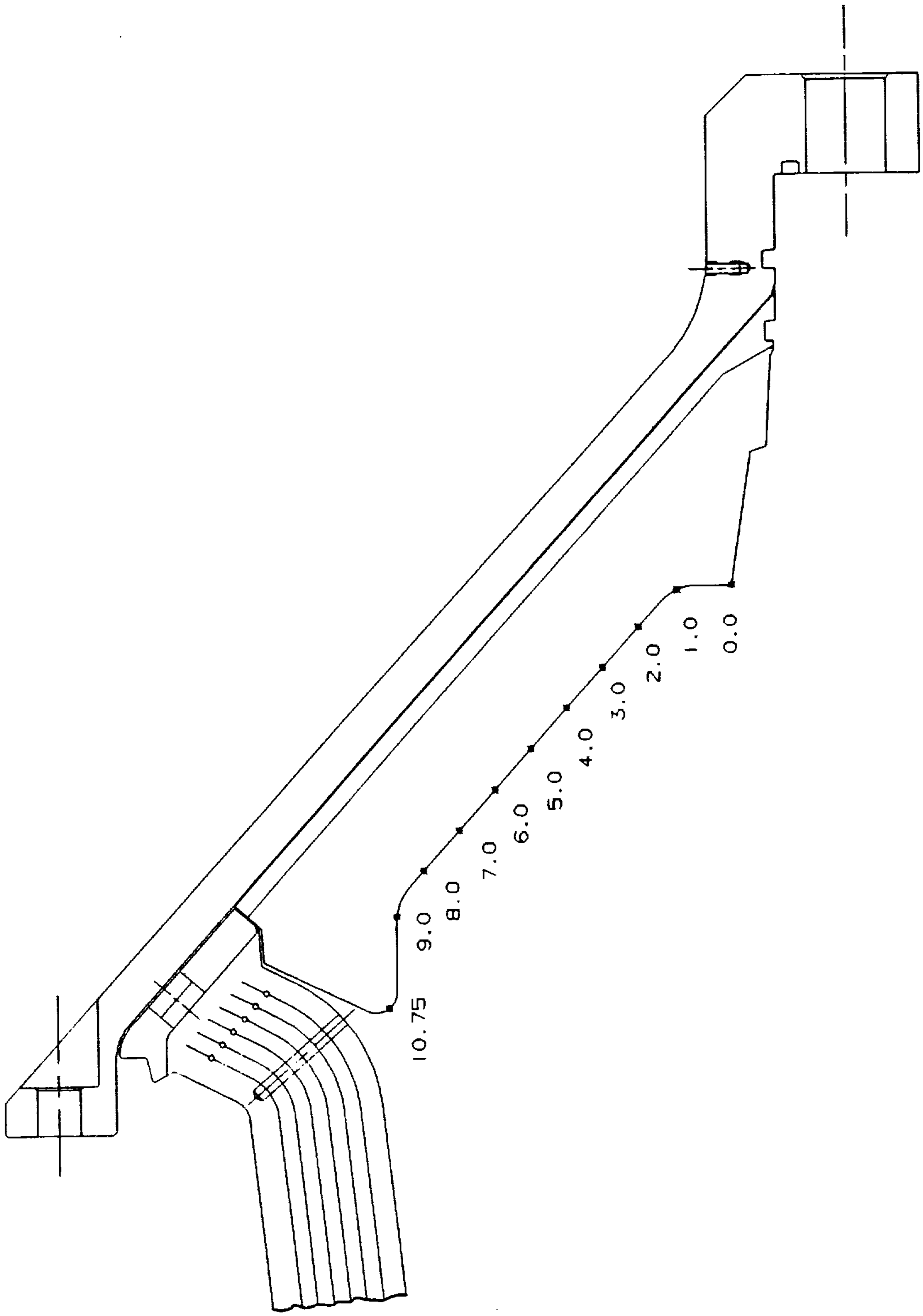

Figure 50 Fixed Housing Liner Erosion Measurement Station

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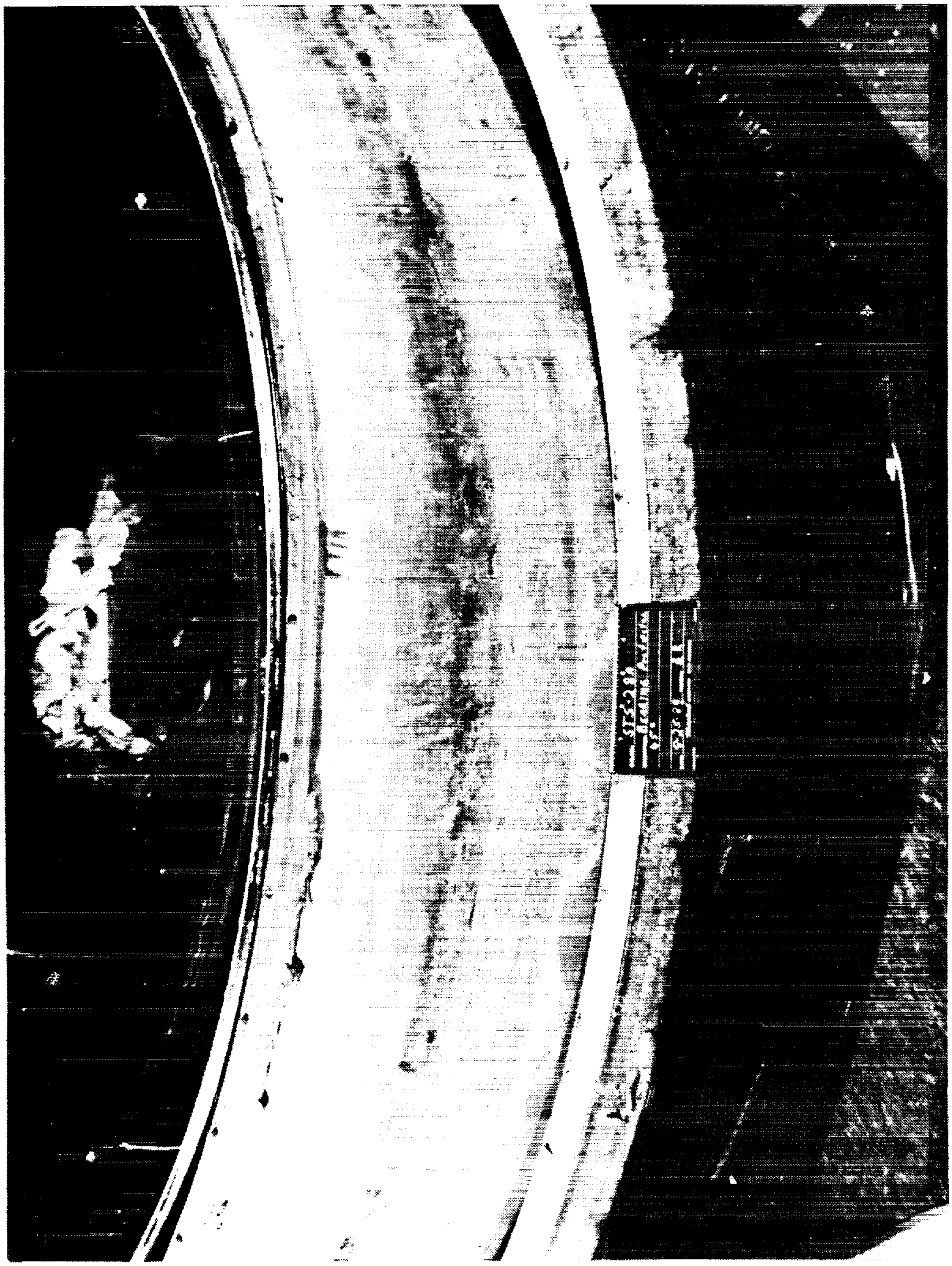

Figure 51 STS-28A Bearing Protector (45 deg)

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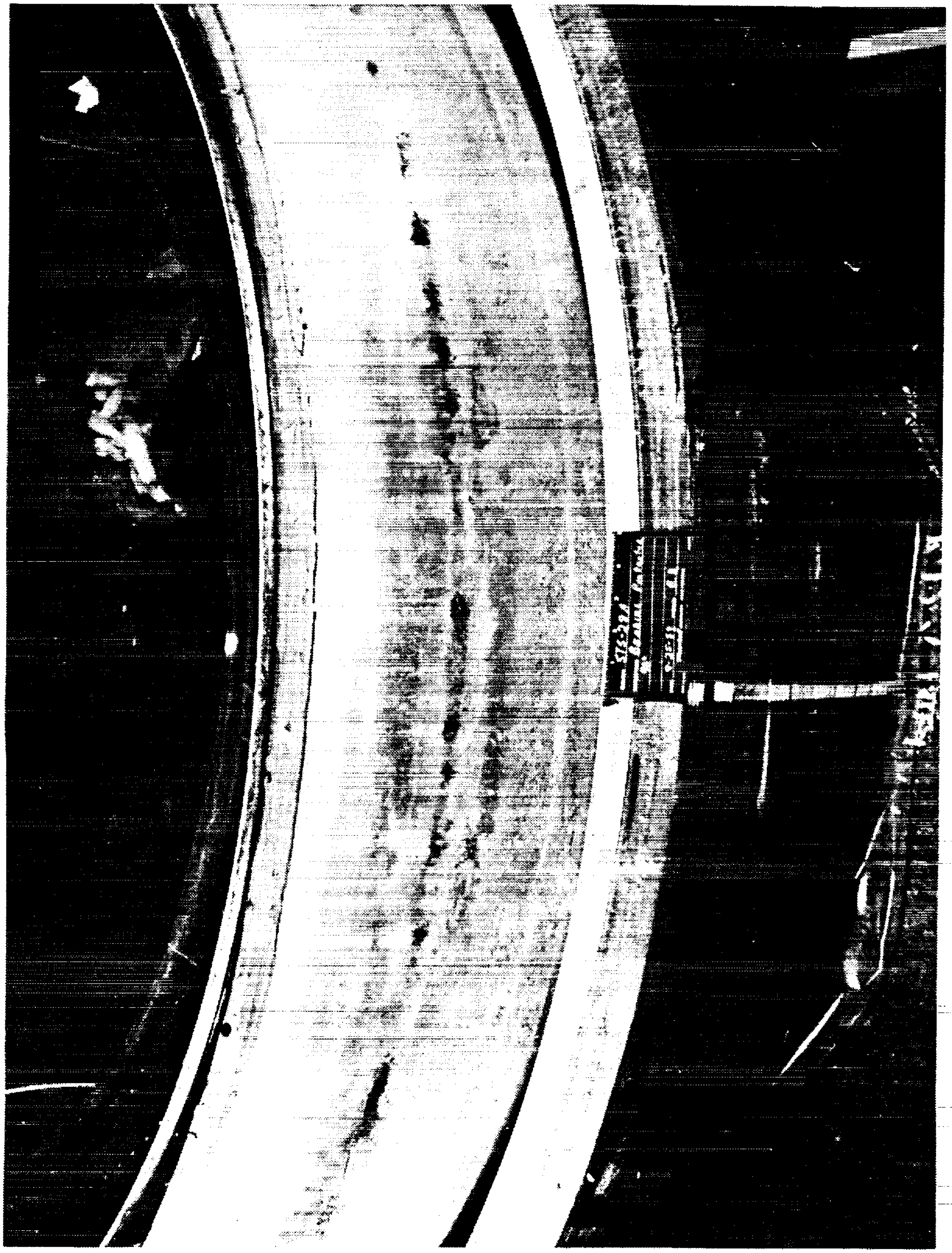

Figure 52 STS-28A Bearing Protector (90 deg)

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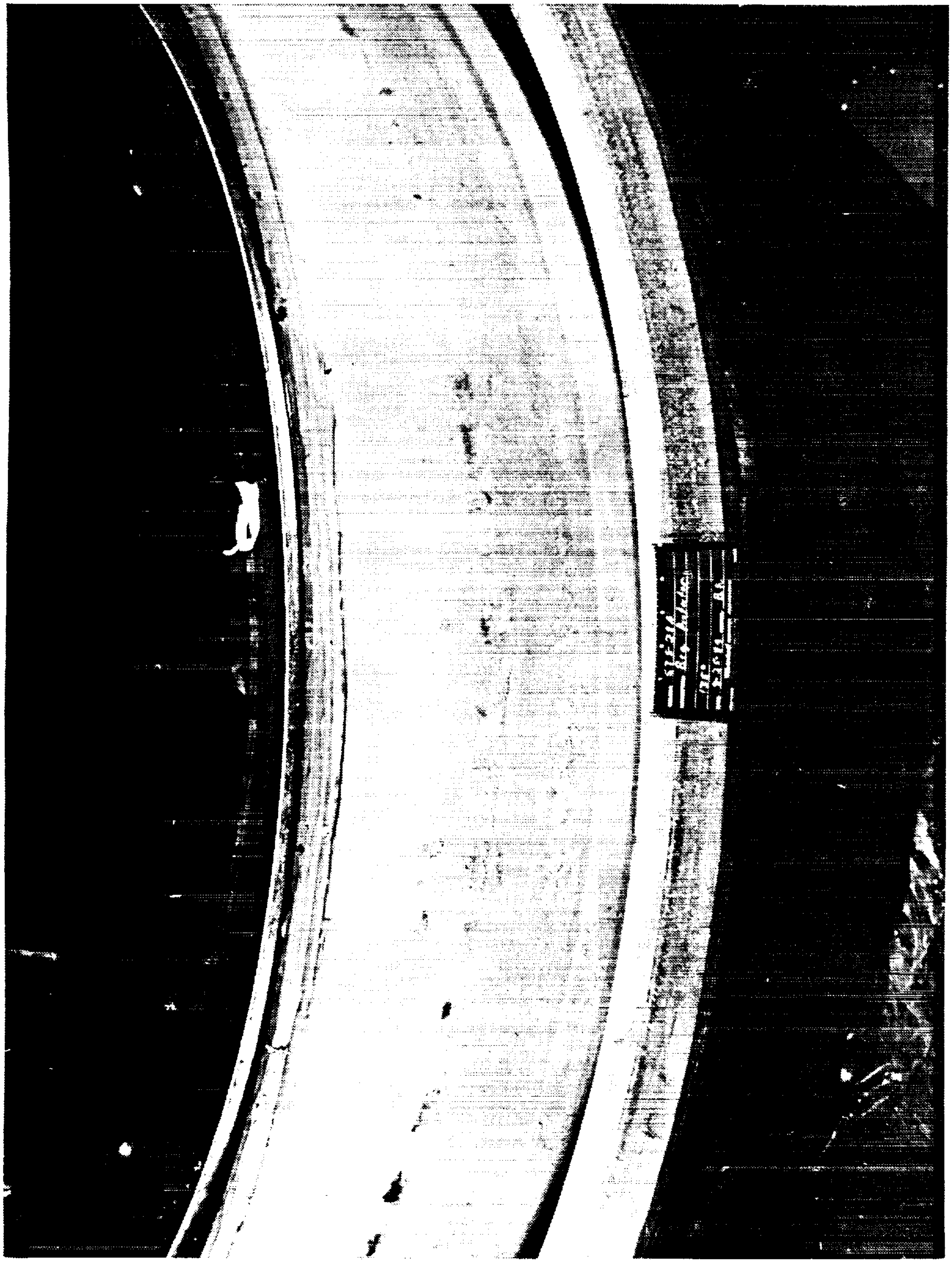

Figure 53 STS-28A Bearing Protector (135 deg)

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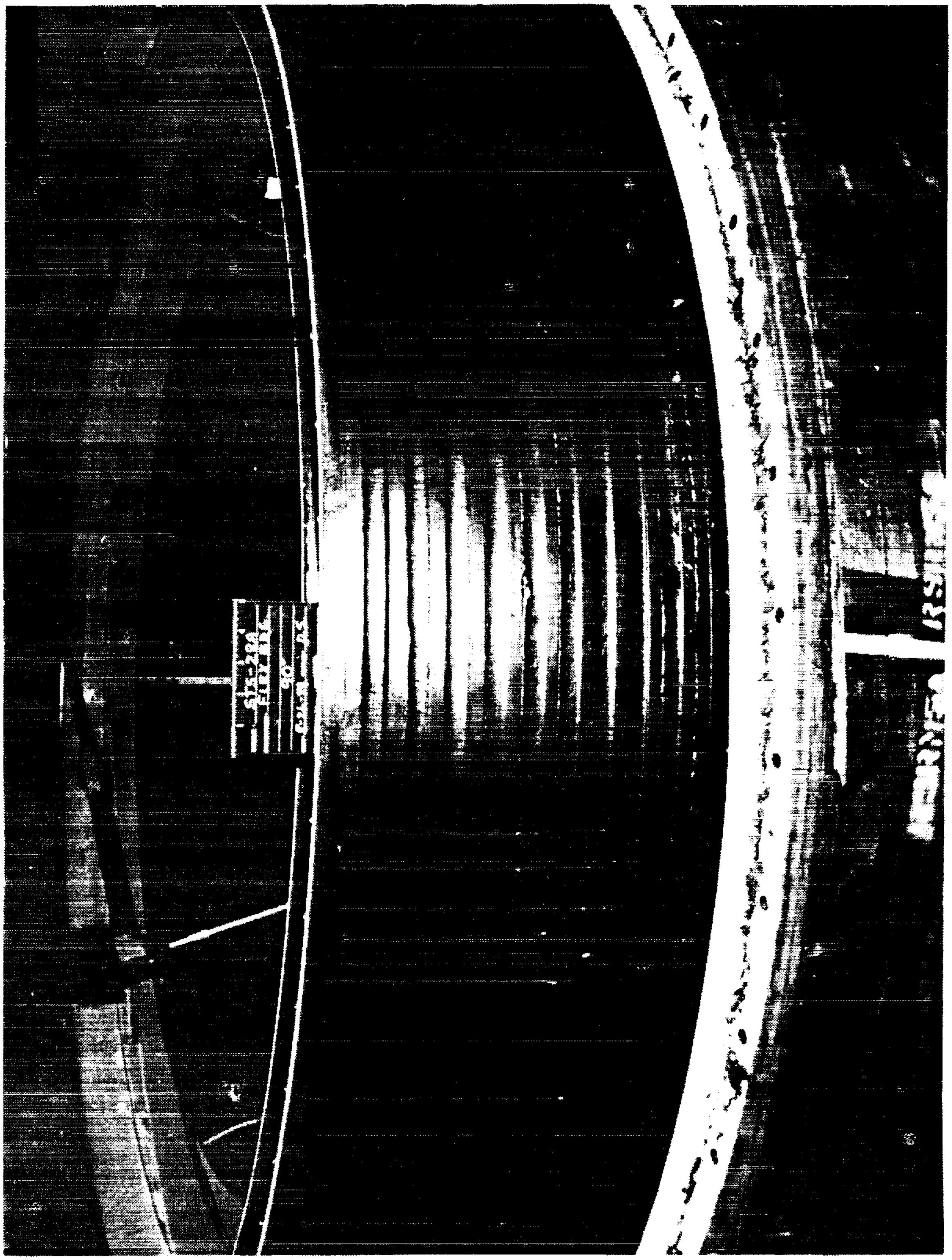

Figure 54 STS-28A Flex Bearing (90 deg)

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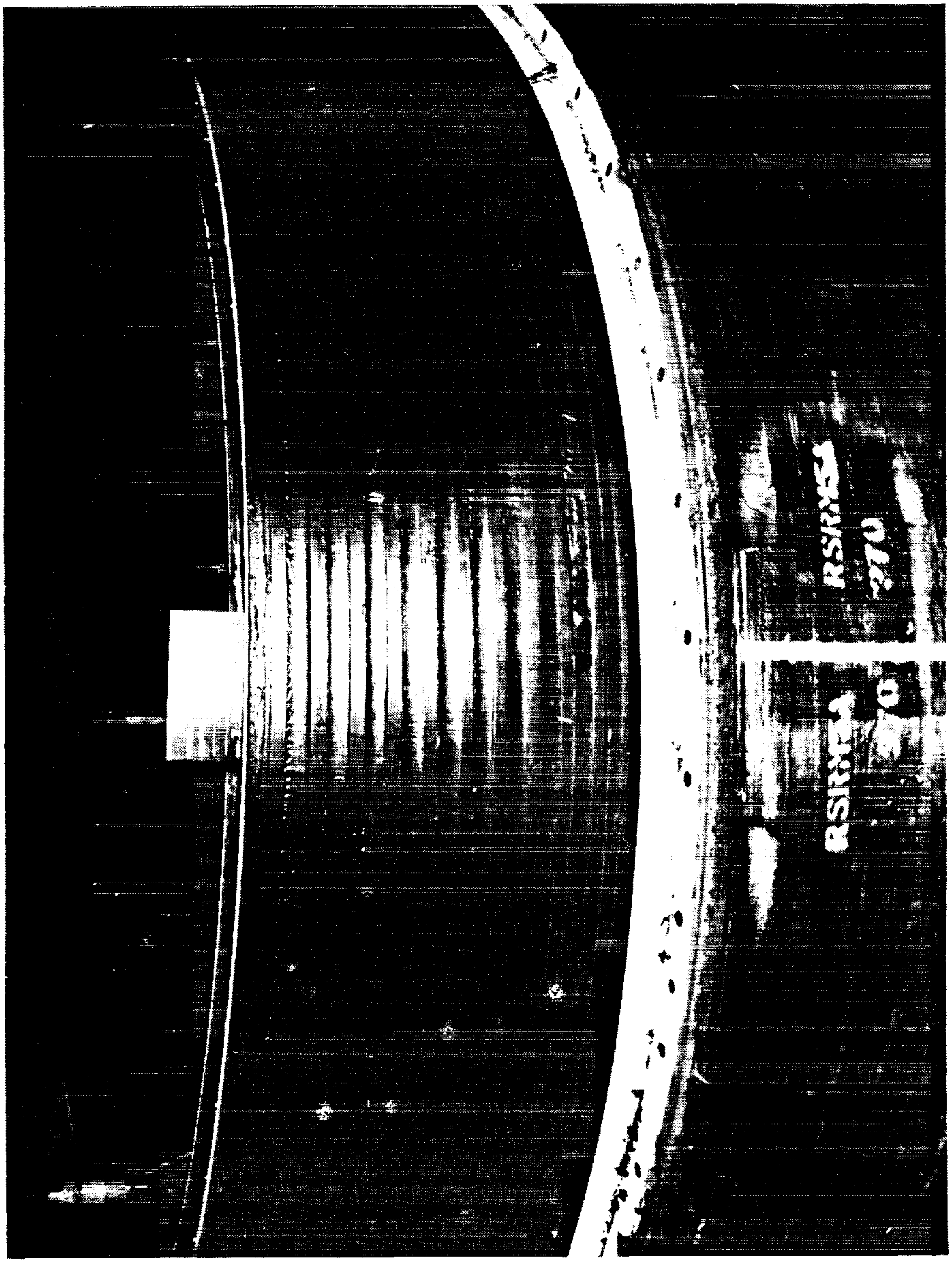

Figure 55 STS-28A Flex Bearing (270 deg)

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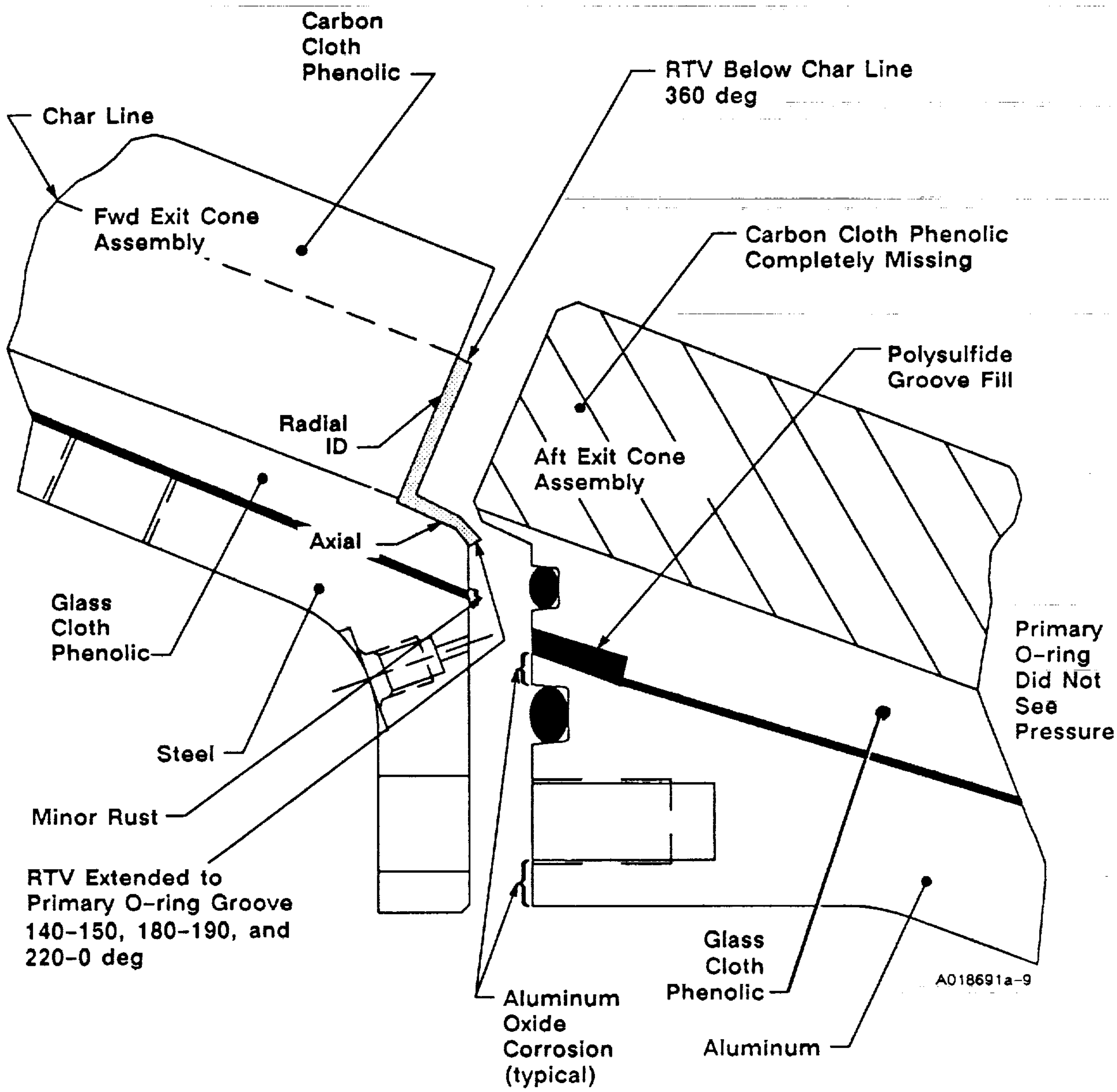

Figure 56 STS-28A Forward Exit Cone-to-Aft Exit Cone Joint Interface (Joint #1)

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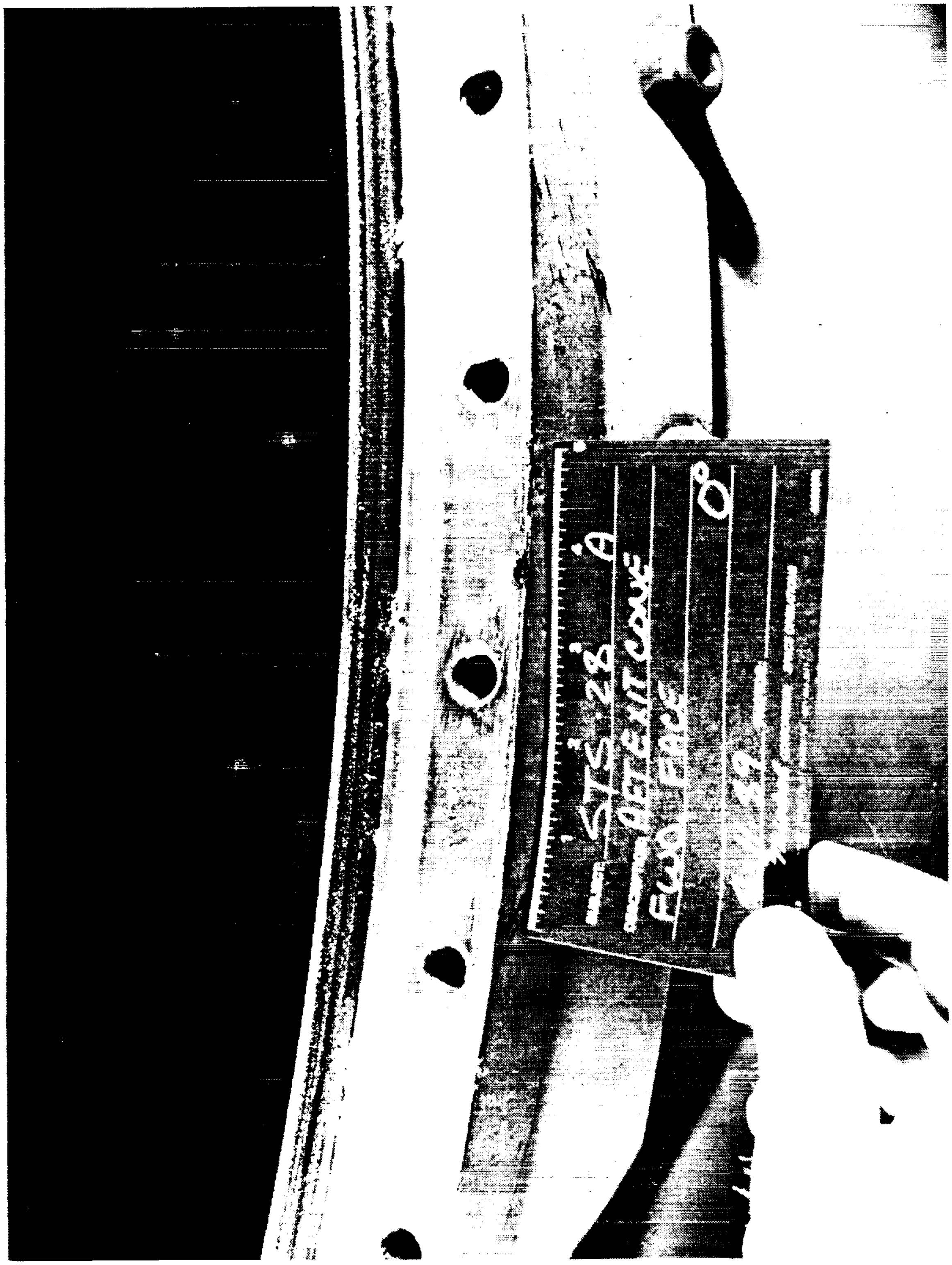

Figure 57 STS-28A Aft Exit Cone Forward End (0 deg)

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Figure 58 STS-28A Aft Exit Cone Forward End (90 deg)

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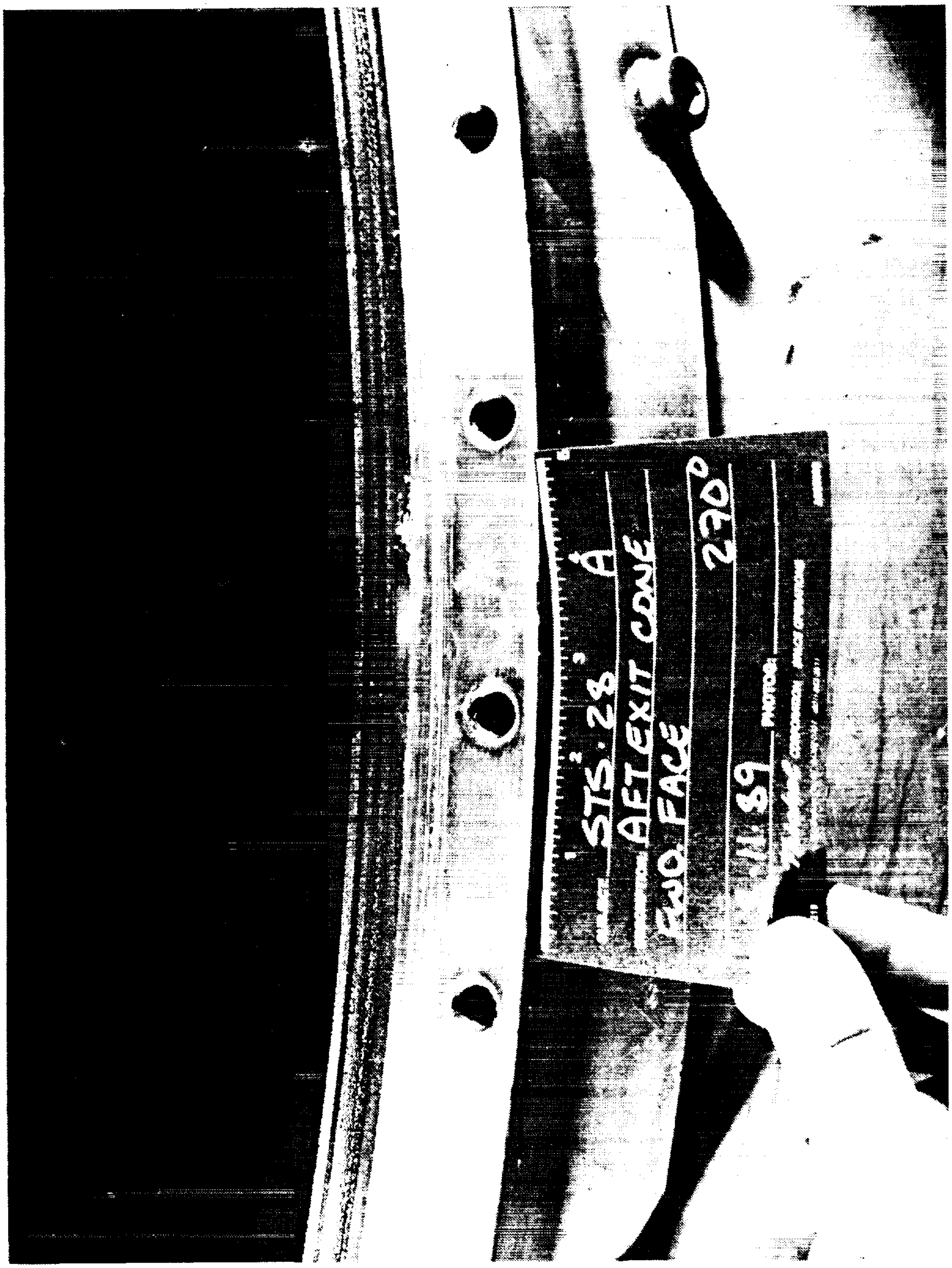

Figure 59 STS-28A Aft Exit Cone Forward End (270 deg)

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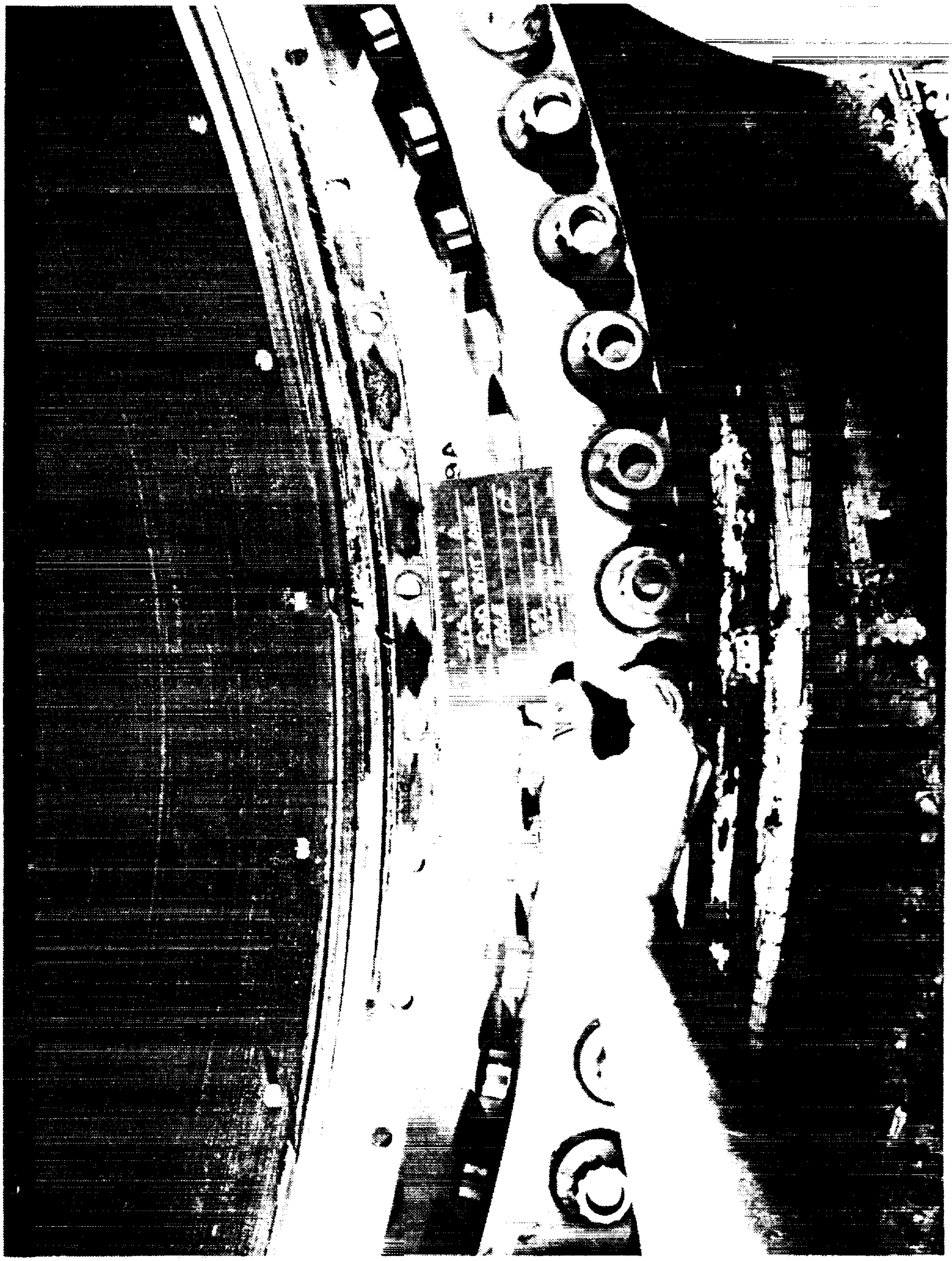

Figure 60 STS-28A Forward Exit Cone - Aft End (0 deg)

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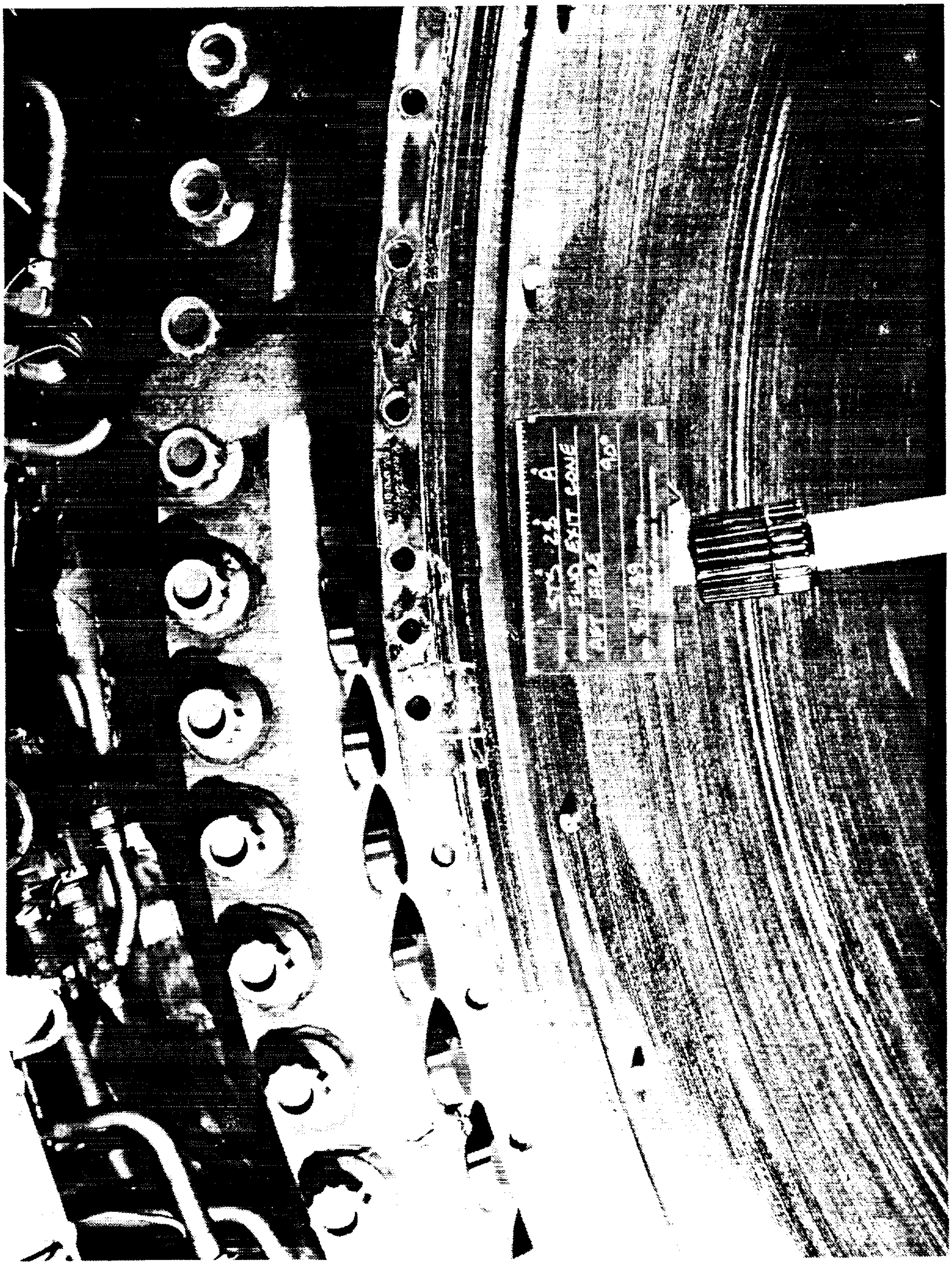

Figure 61 STS-28A Forward Exit Cone - Aft End (90 deg)

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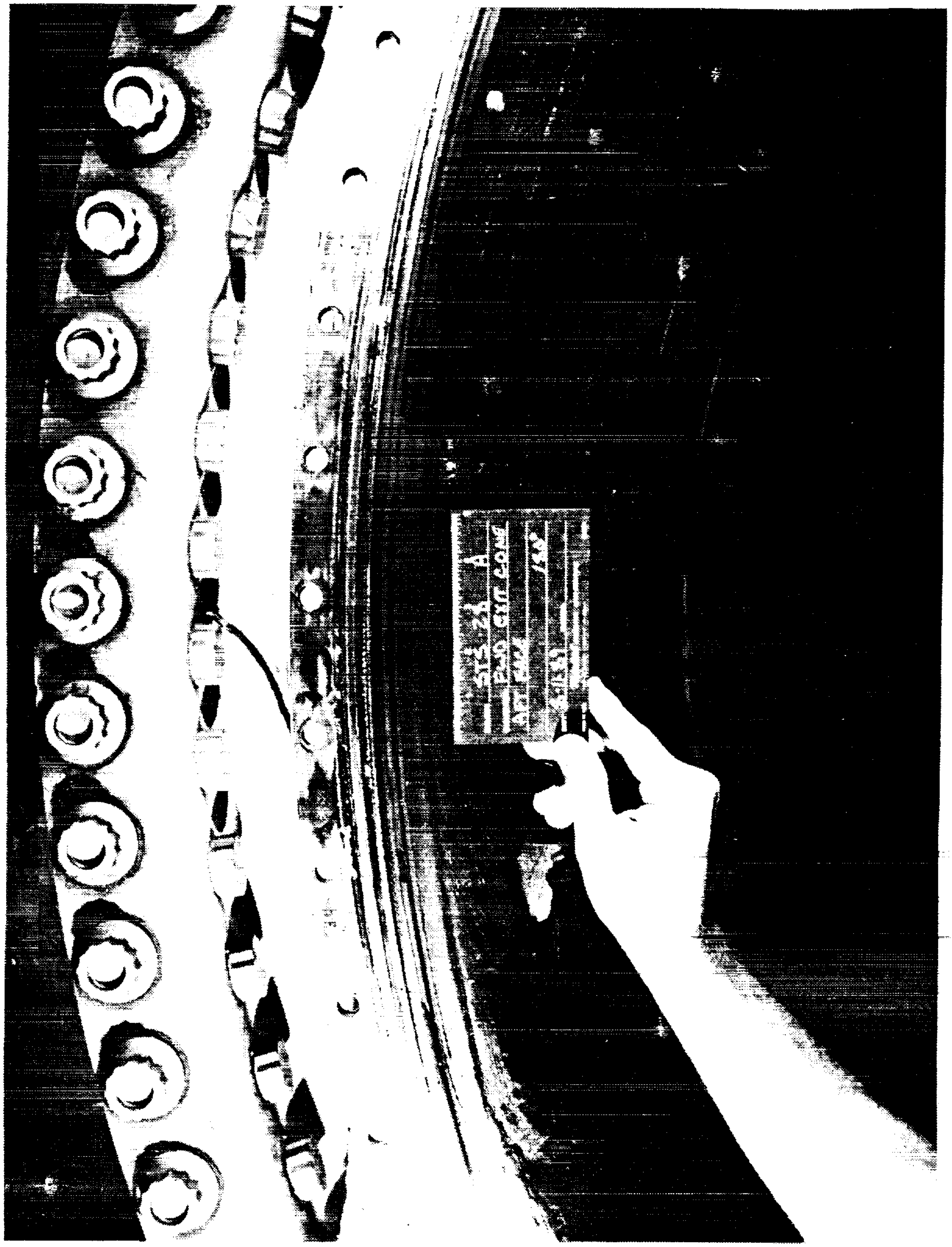

Figure 62 STS-28A Forward Exit Cone - Aft End (180 deg)

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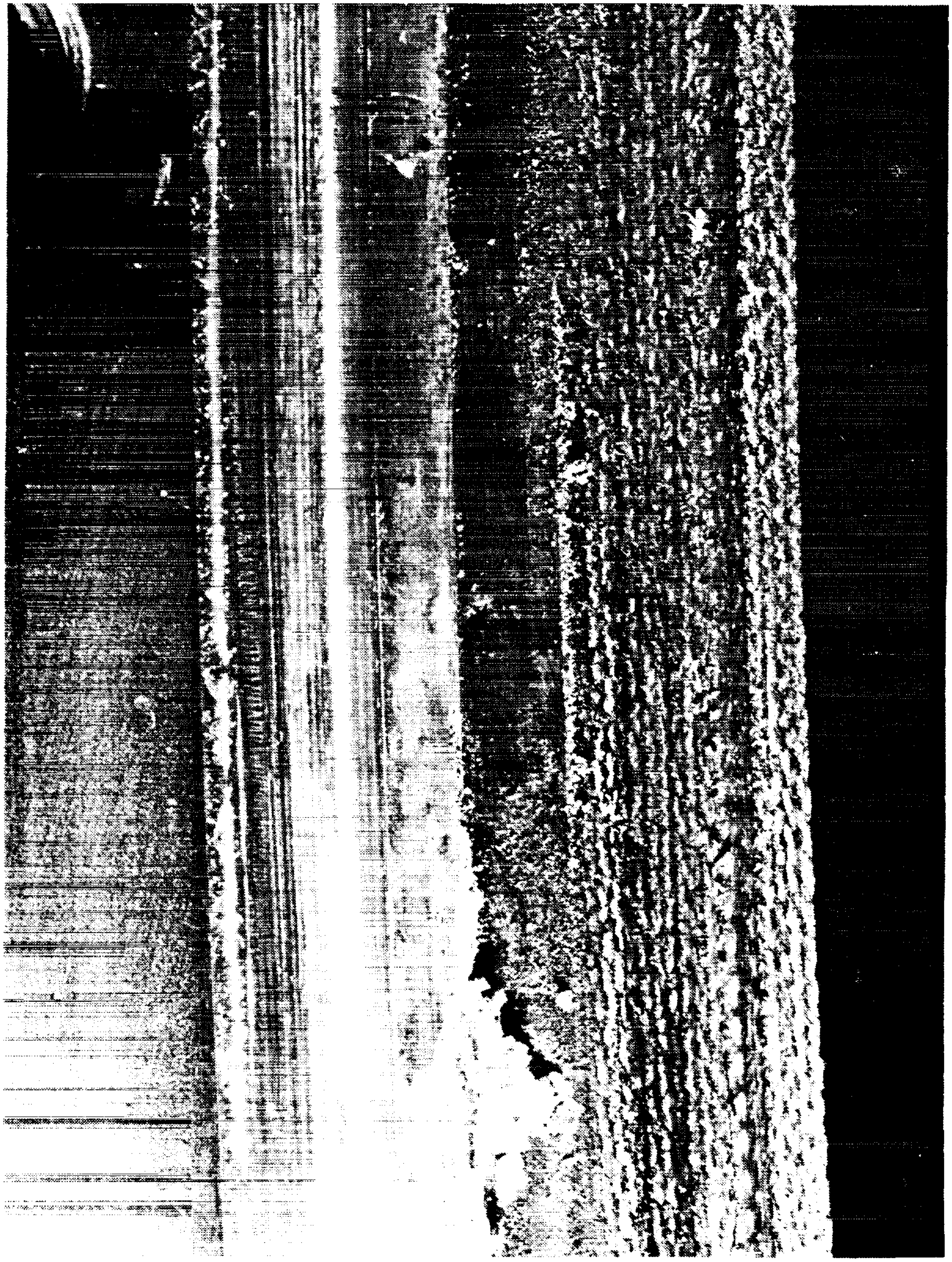

Figure 63 STS-28A Aft Exit Cone Forward Face Powder Residue (270 deg)

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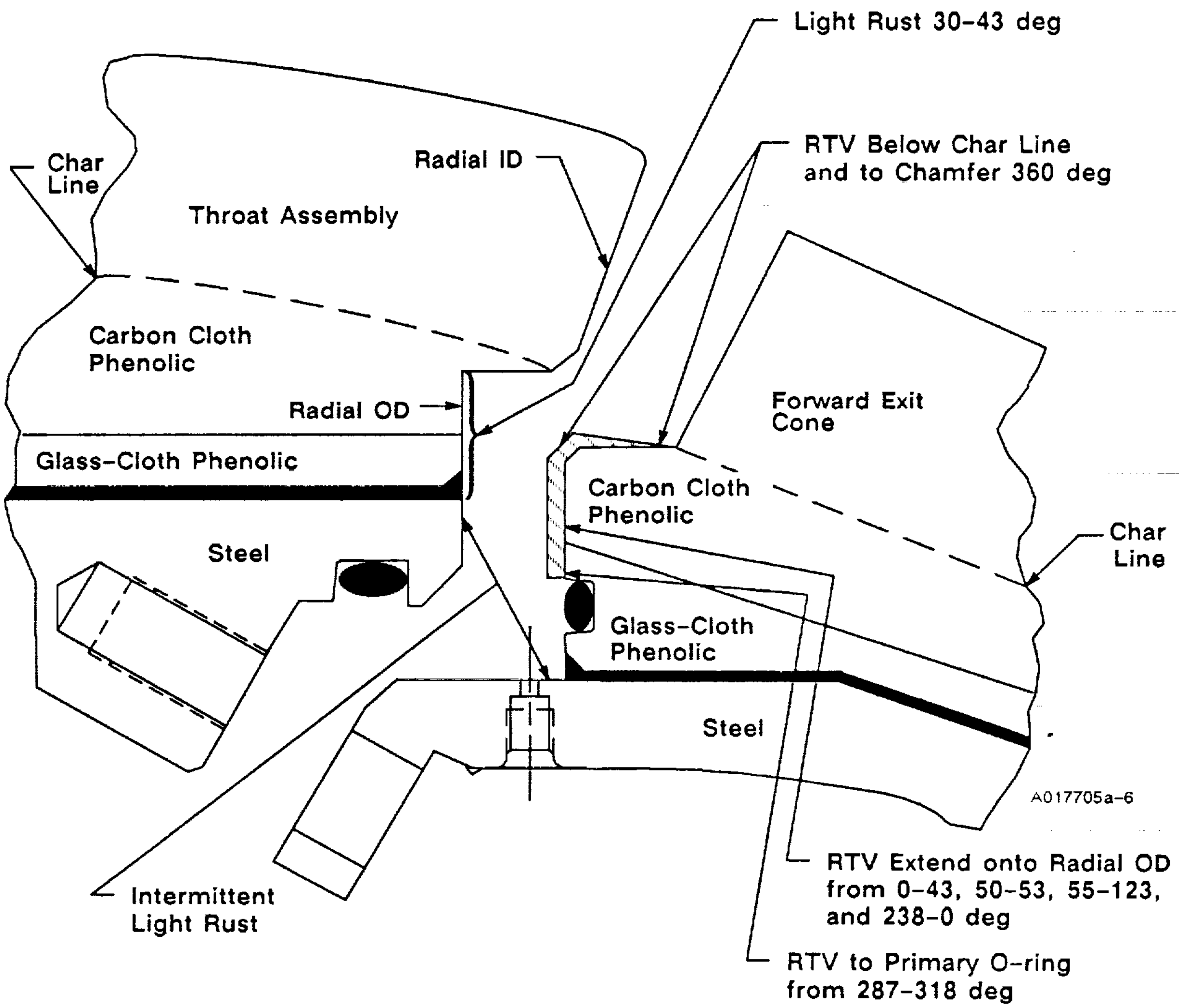

Figure 64 STS-28B—Throat/Forward Exit Cone Joint (Joint #4)

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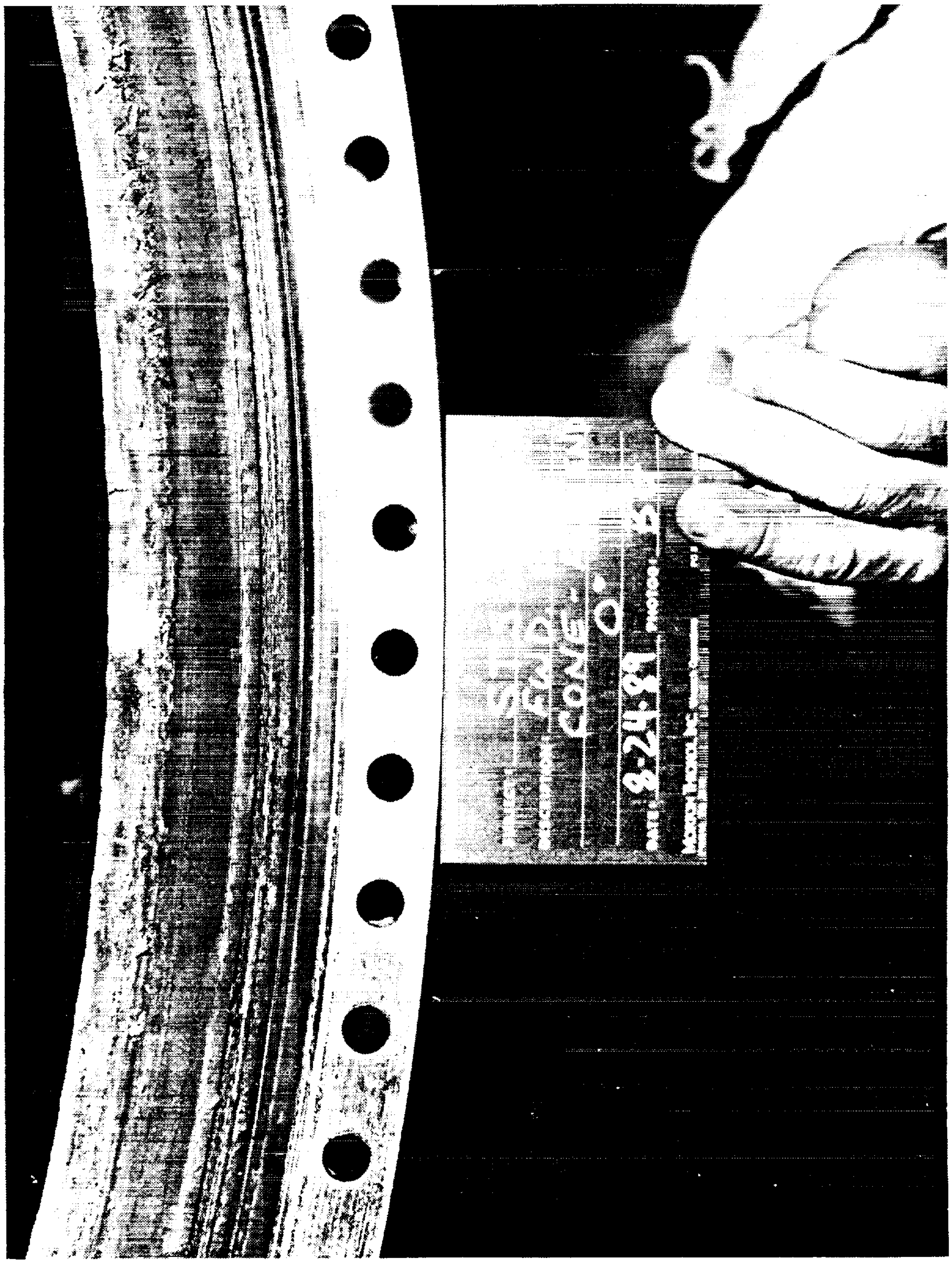

Figure 65 STS-28A Forward Exit Cone - Forward End (0 deg)

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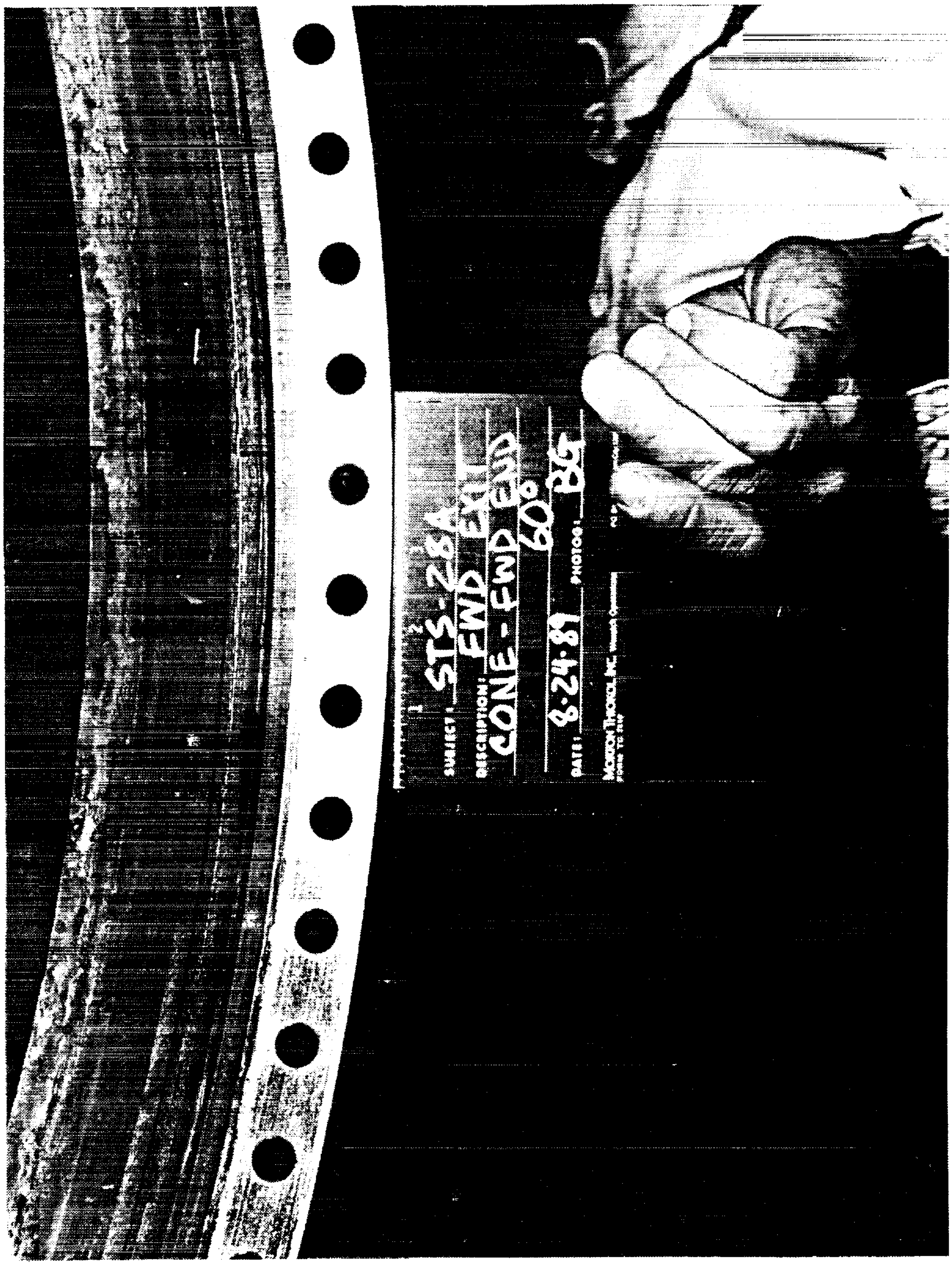

Figure 66 STS-28A Forward Exit Cone - Forward End (60 deg)

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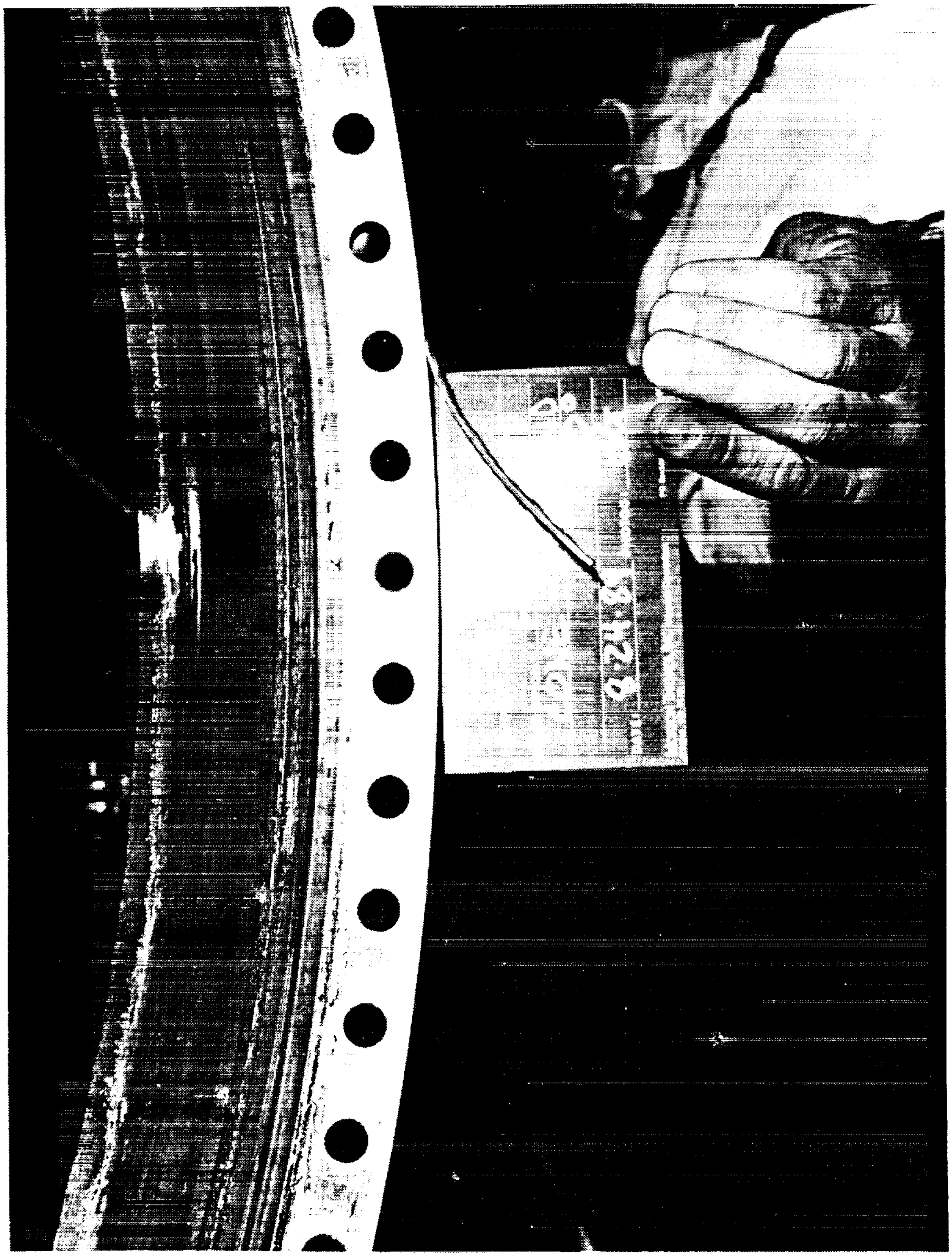

Figure 67 STS-28A Forward Exit Cone - Forward End (180 deg)

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Figure 68 STS-28A Throat Aft End (0 deg)

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Figure 69 STS-28A Throat Aft End (60 deg)

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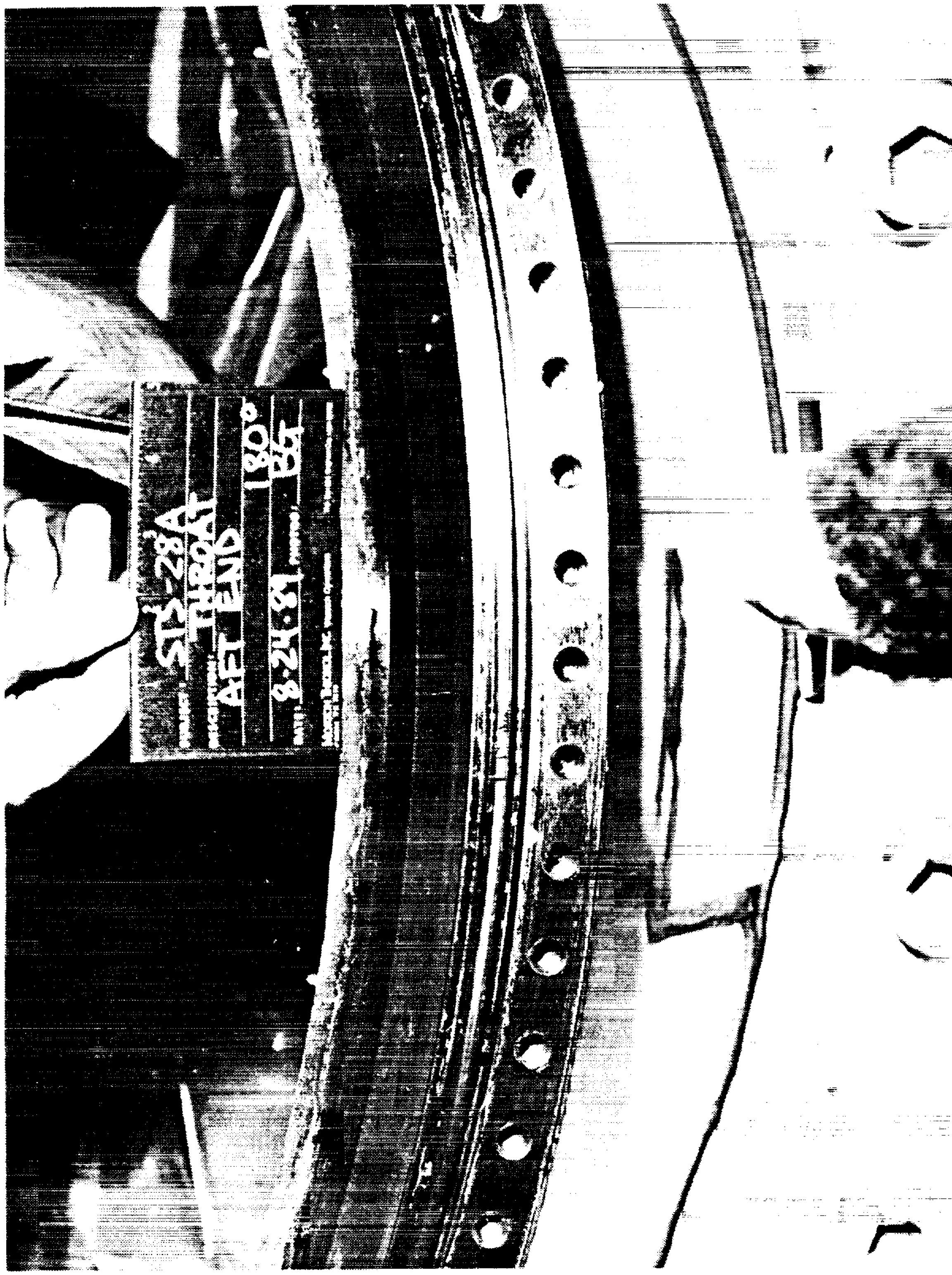

Figure 70 STS-28A Throat Aft End (180 deg)

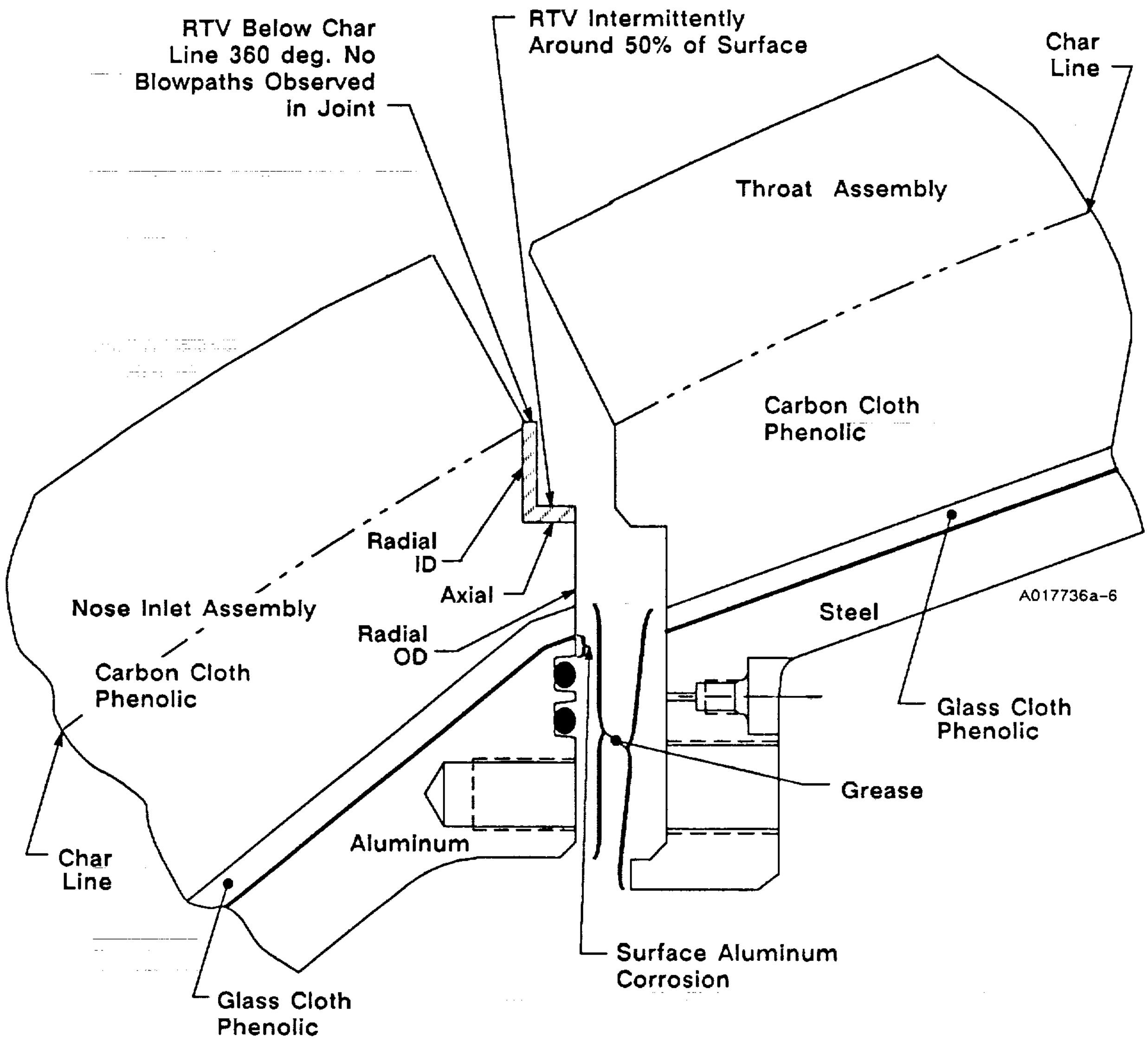

Figure 71 STS-28A—Nose Inlet/Throat Housing Joint (Joint #3)

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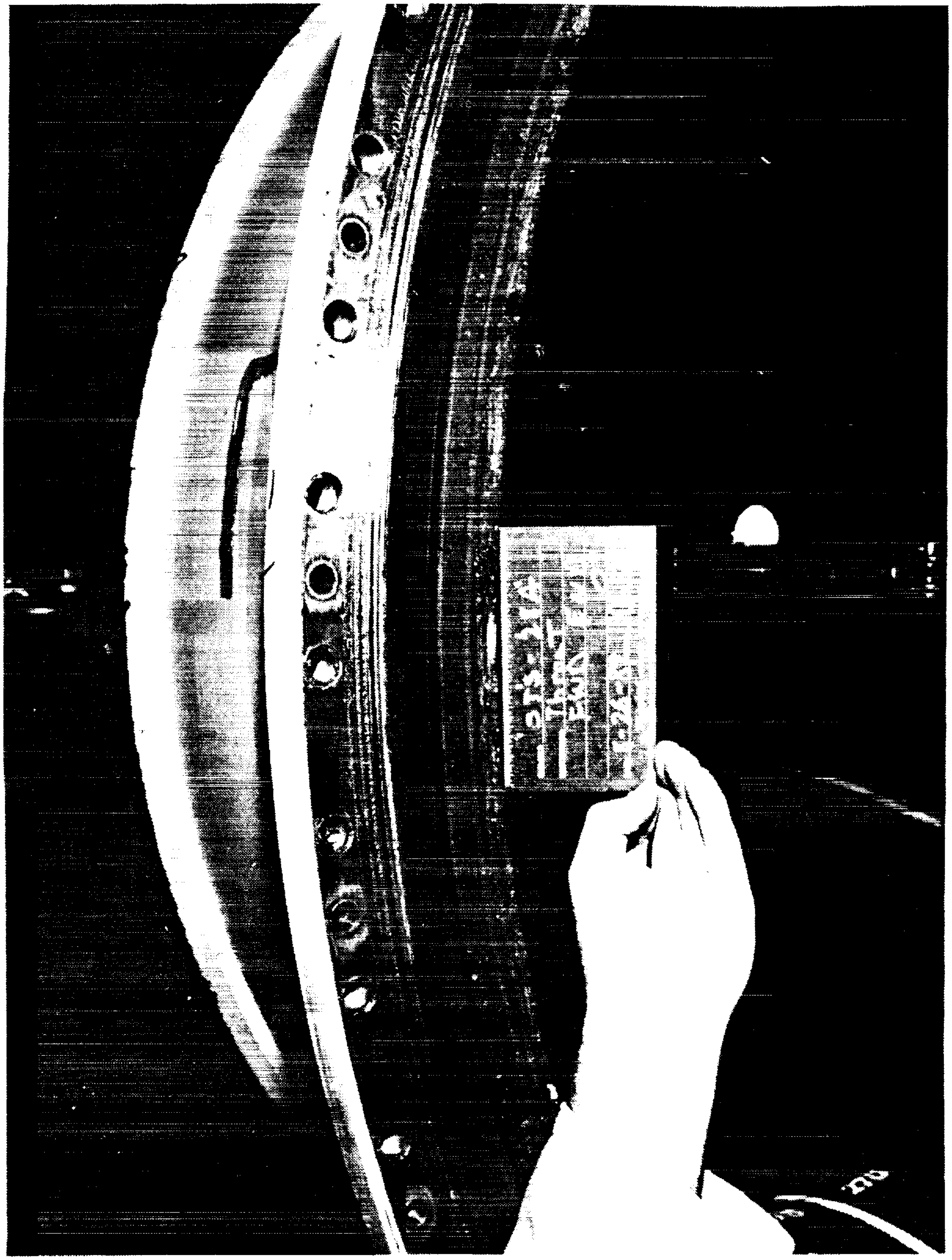

Figure 72 STS-28A Throat - Forward End (0 deg)

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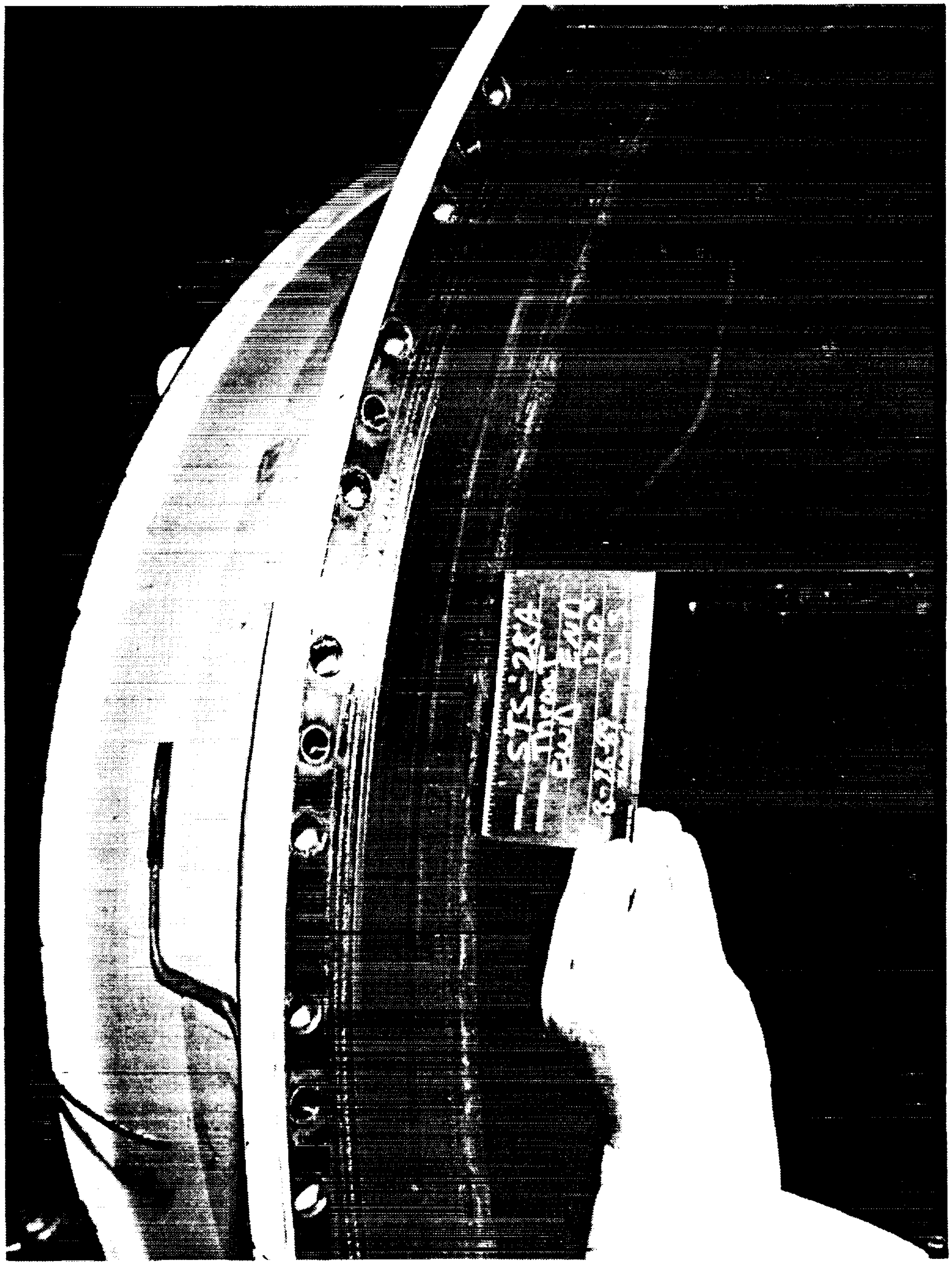

Figure 73 STS-28A Throat - Forward End (120 deg)

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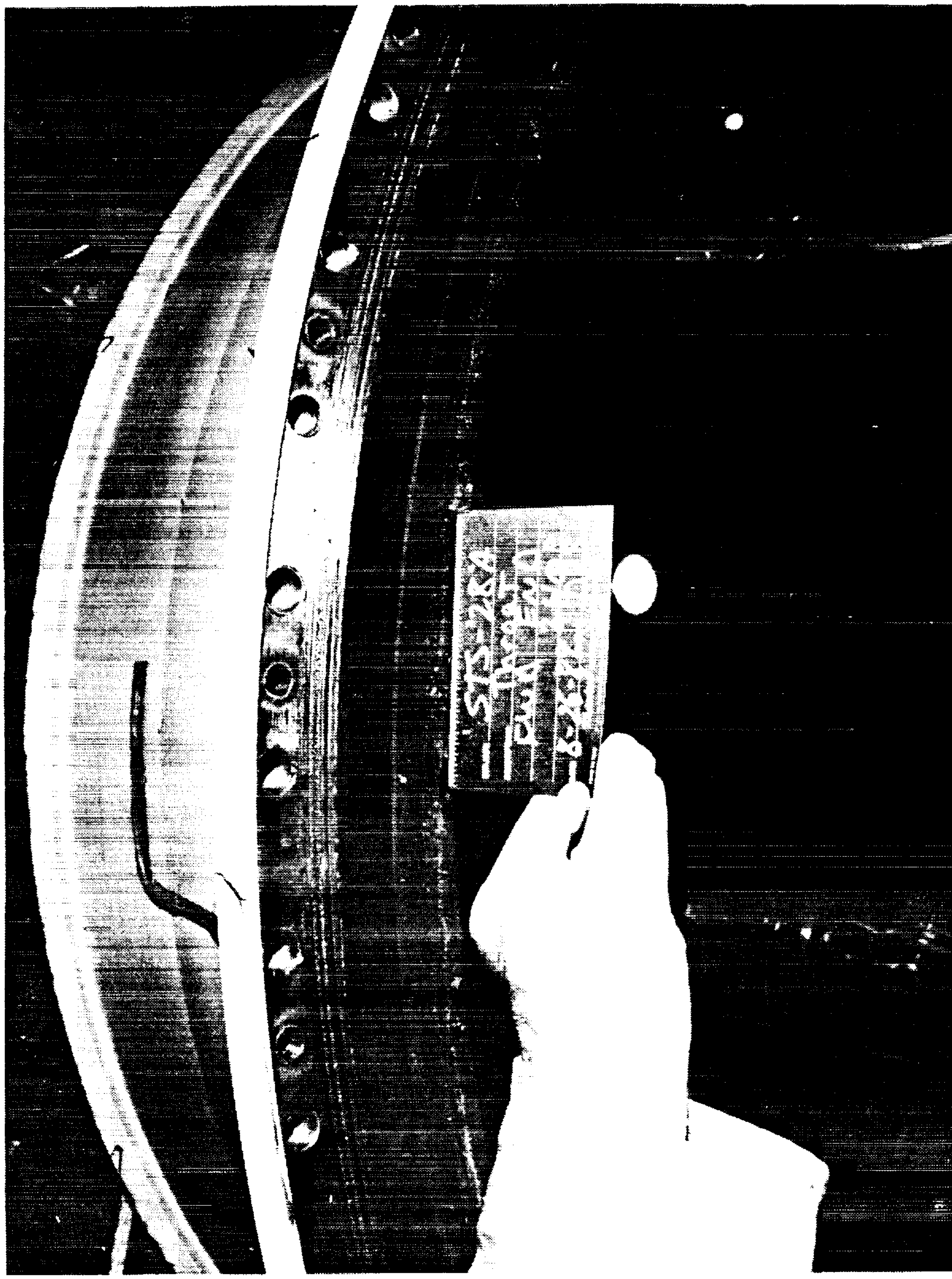

Figure 74 STS-28A Throat - Forward End (240 deg)

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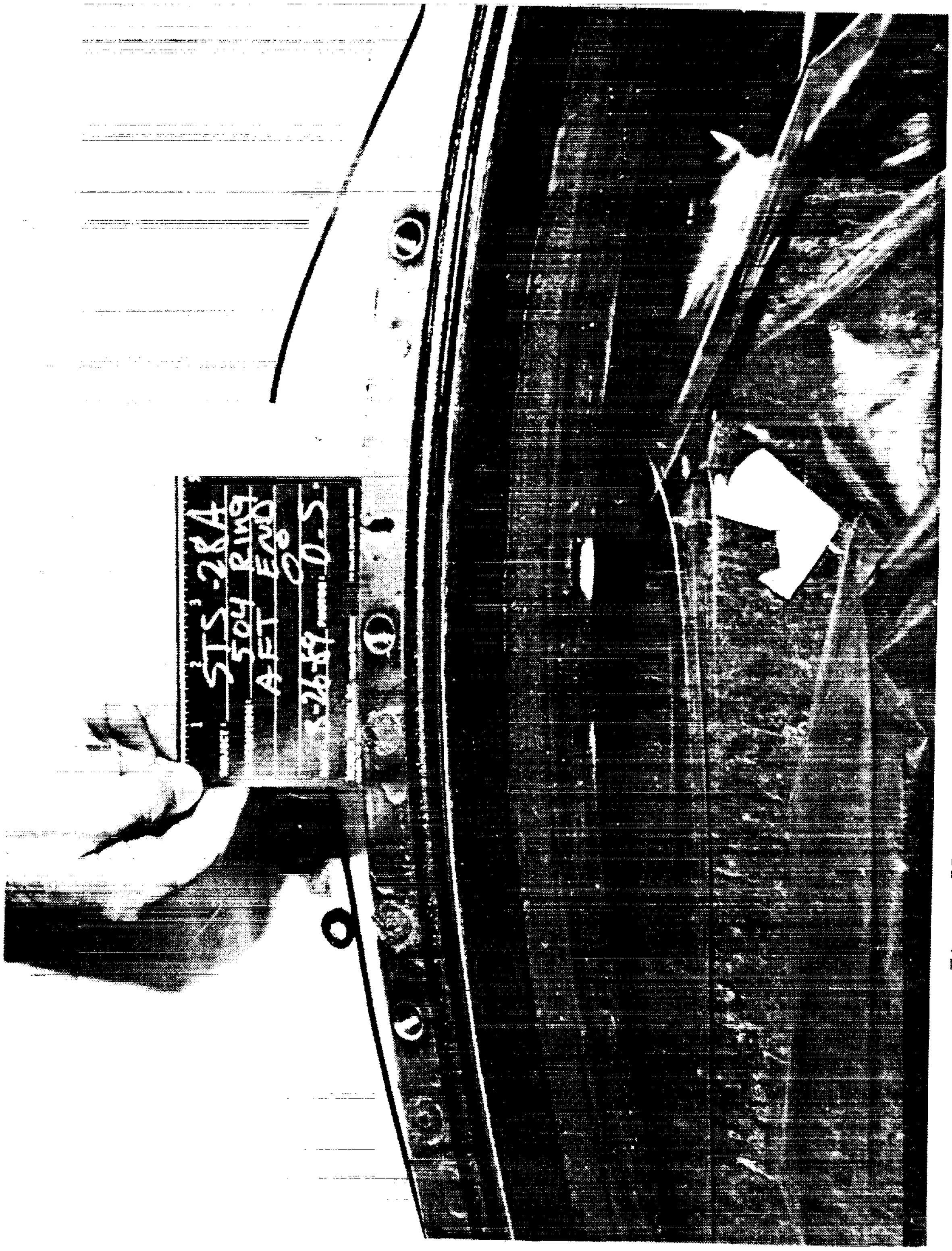

Figure 75 STS-28A Aft Inlet (-504) Ring - Aft End (0 deg)

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Figure 76 STS-28A Aft Inlet (-504) Ring - Aft End (120 deg)

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Figure 77 STS-28A Aft Inlet (-504) Ring - Aft End (240 deg)

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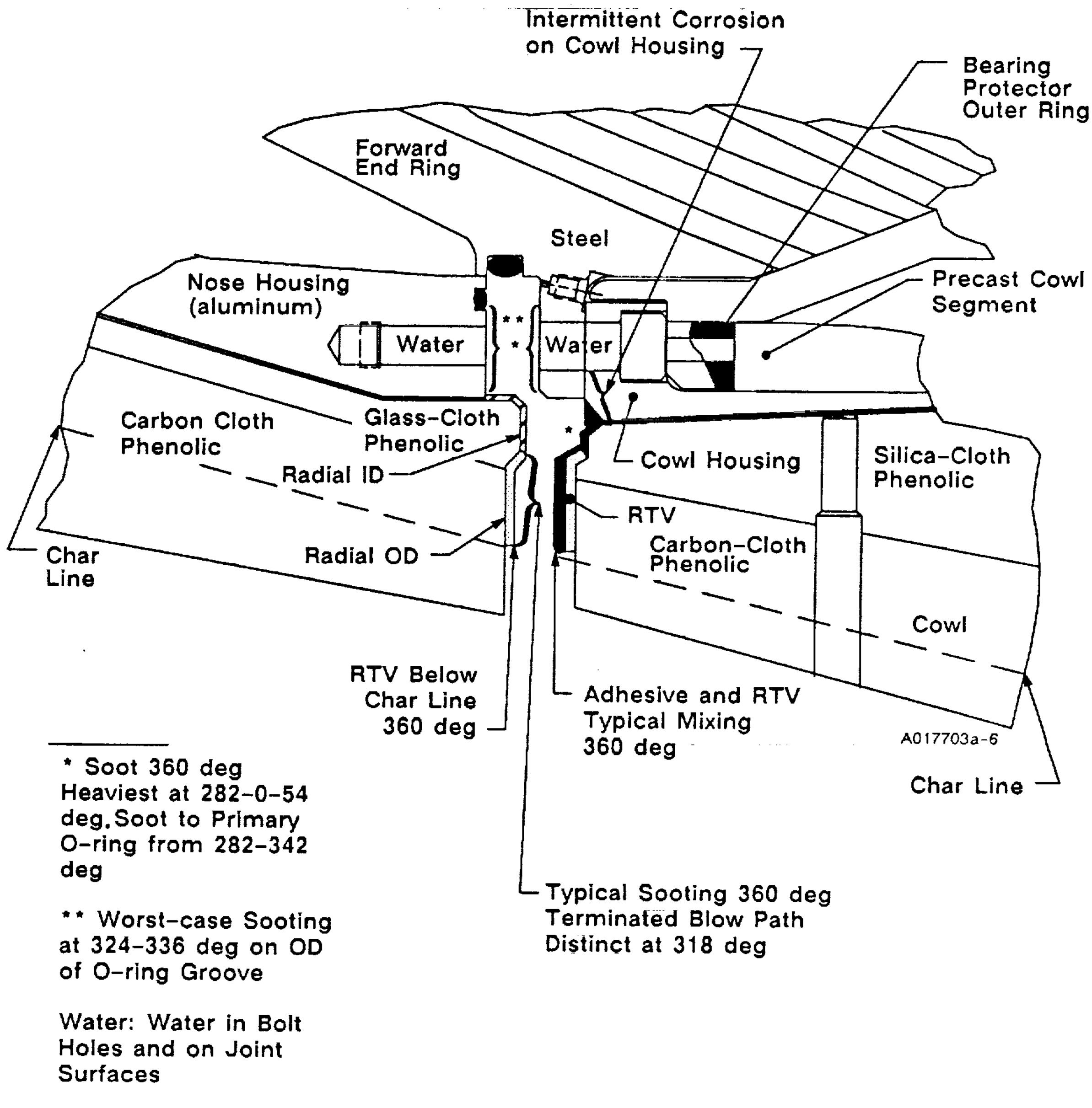

Figure 78 STS-28A Nose Inlet Housing/Flex Bearing Joint

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Figure 79 Cowl - Forward End (0 deg)

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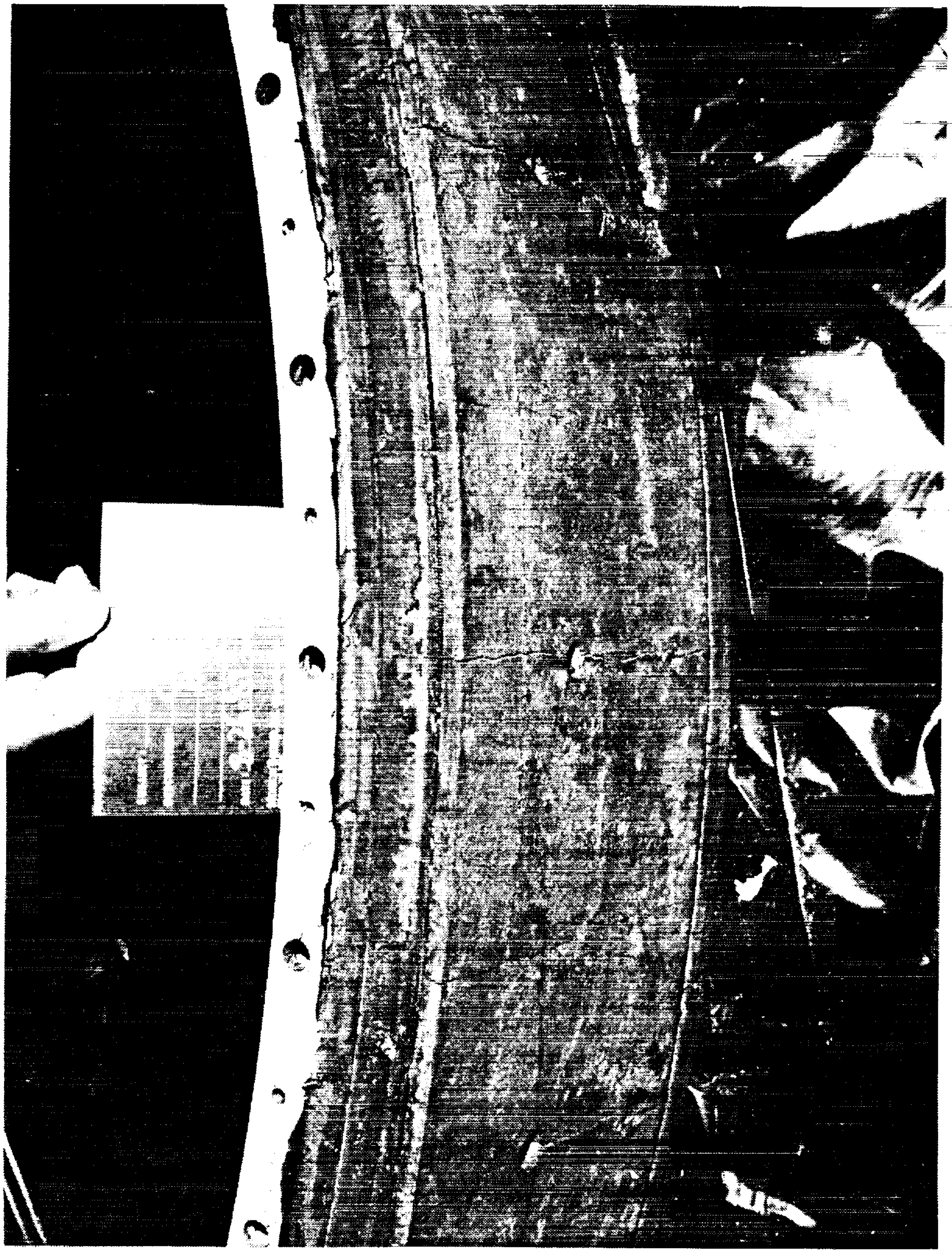

Figure 80 Cowl - Forward End (120 deg)

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Figure 81 STS-28A Cowl - Forward End (240 deg)

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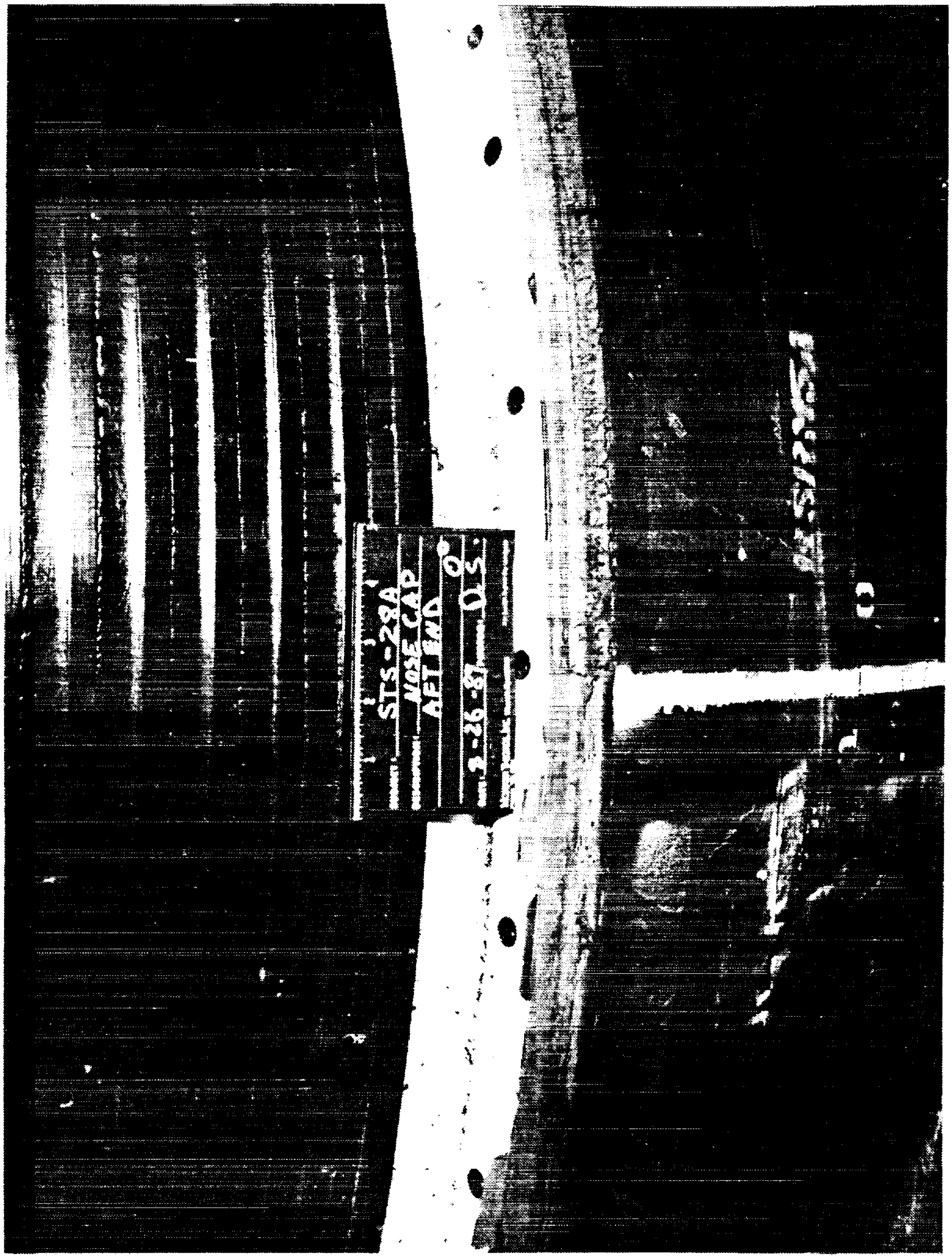

Figure 82 STS-28A Nose Cap - Aft End (0 deg)

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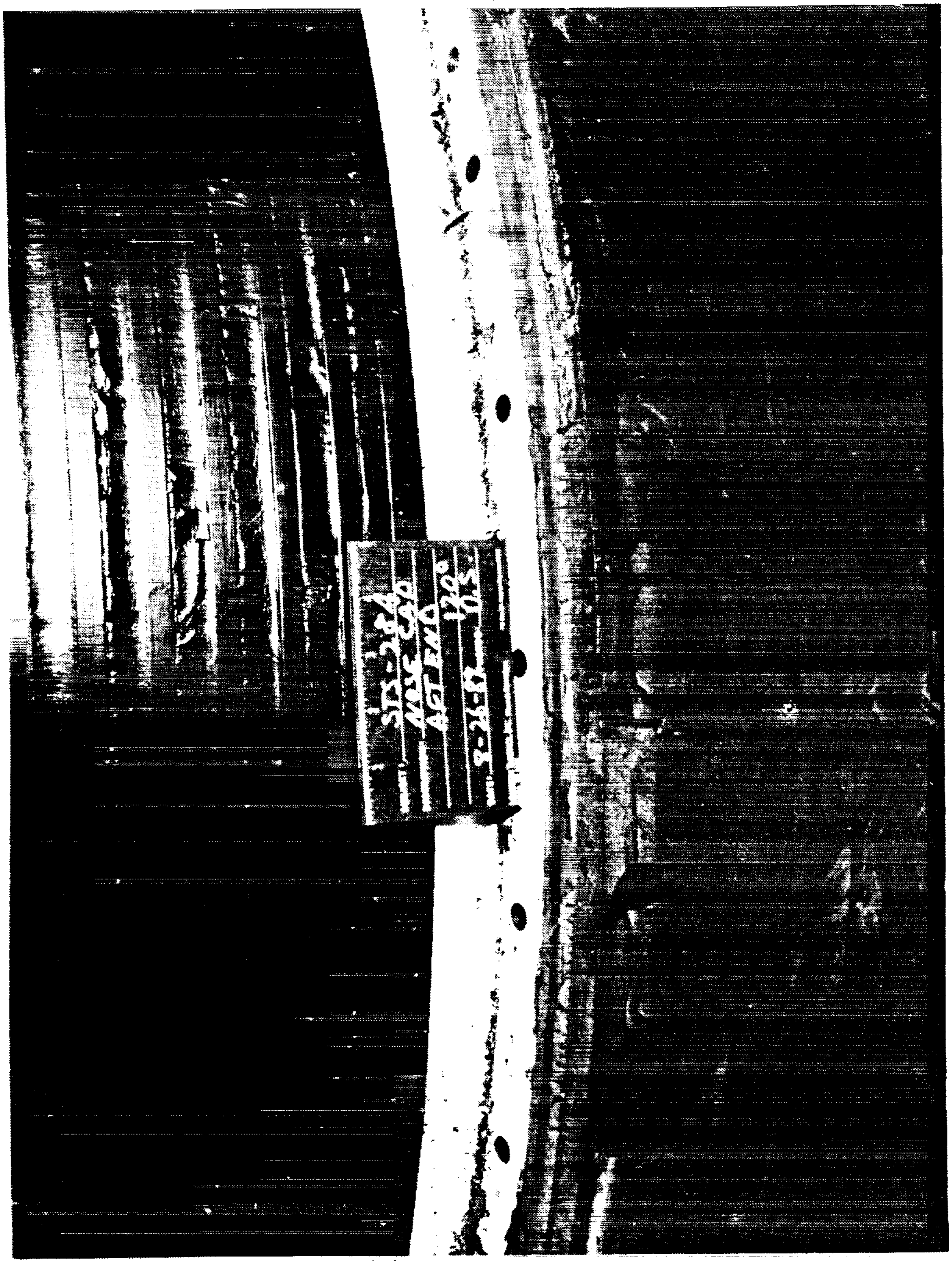

Figure 83 STS-28A Nose Cap - Aft End (120 deg)

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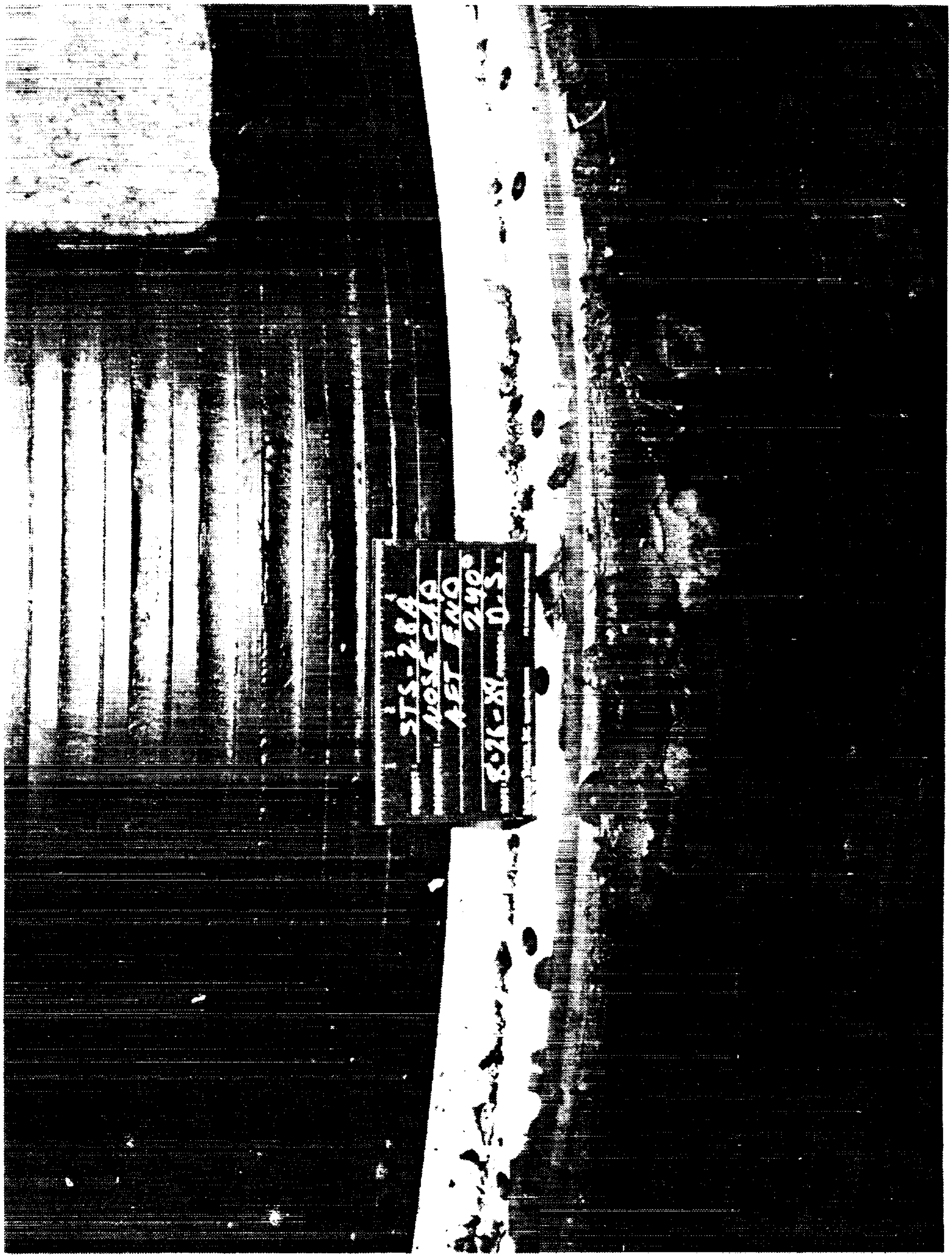

Figure 84 STS-28A Nose Cap - Aft End (240 deg)

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SPACE OPERATIONS

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Figure 85 STS-28A Bearing Forward End Ring (0 deg)

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Figure 86 STS-28A Bearing Forward End Ring (120 deg)

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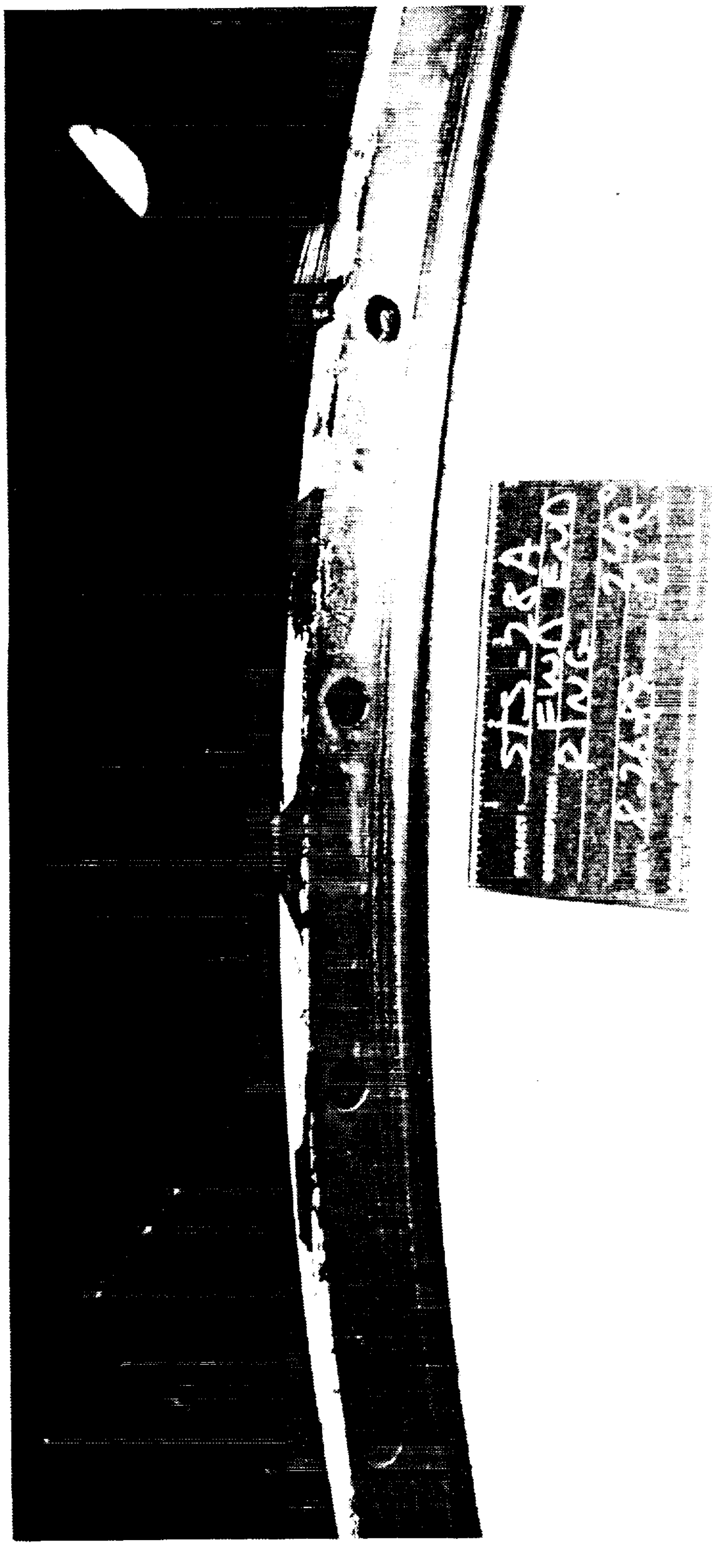

Figure 87 STS-28A Bearing Forward End Ring (240 deg)

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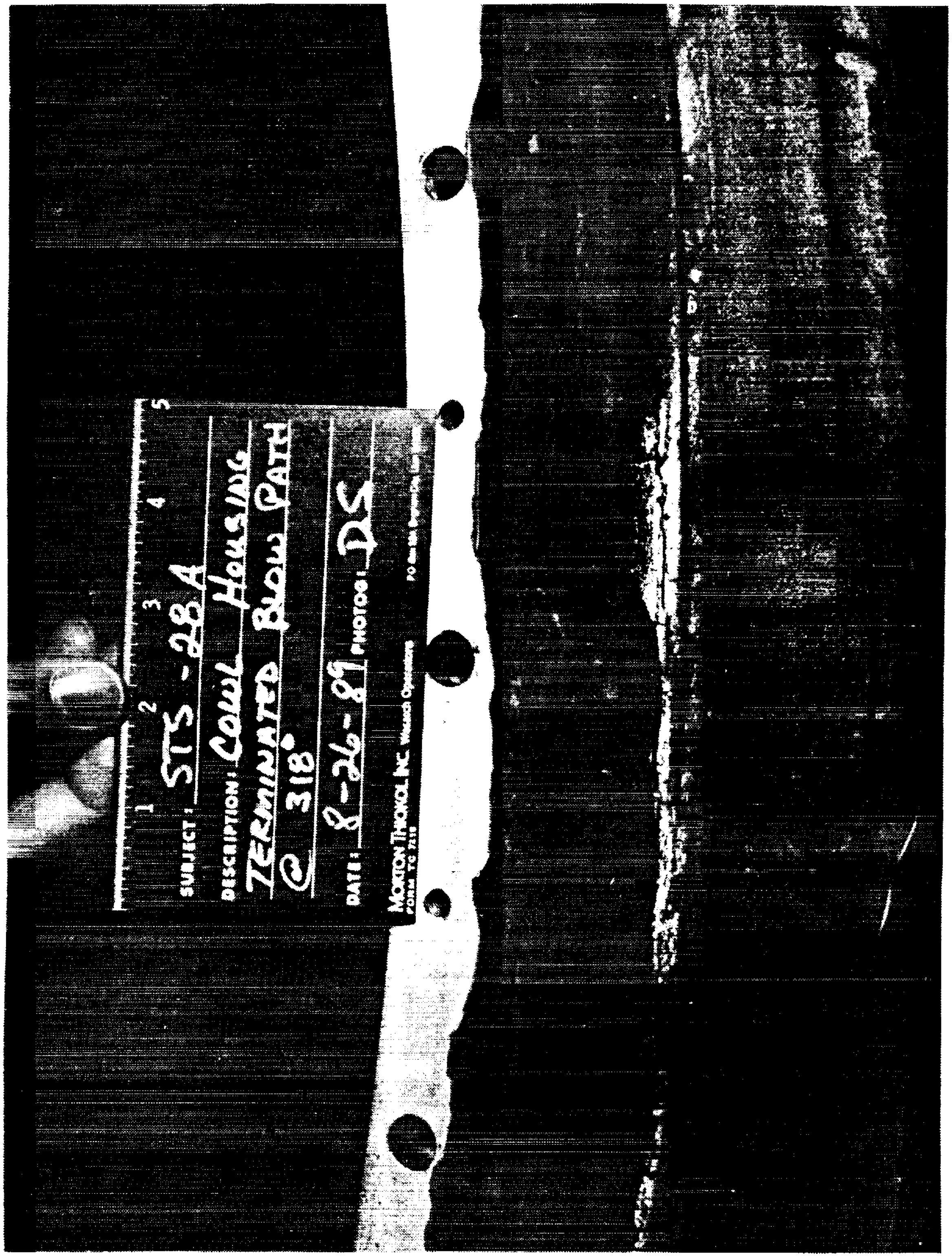

Figure 88 STS-28A Cowl Forward End - Blowpath Location (318 deg)

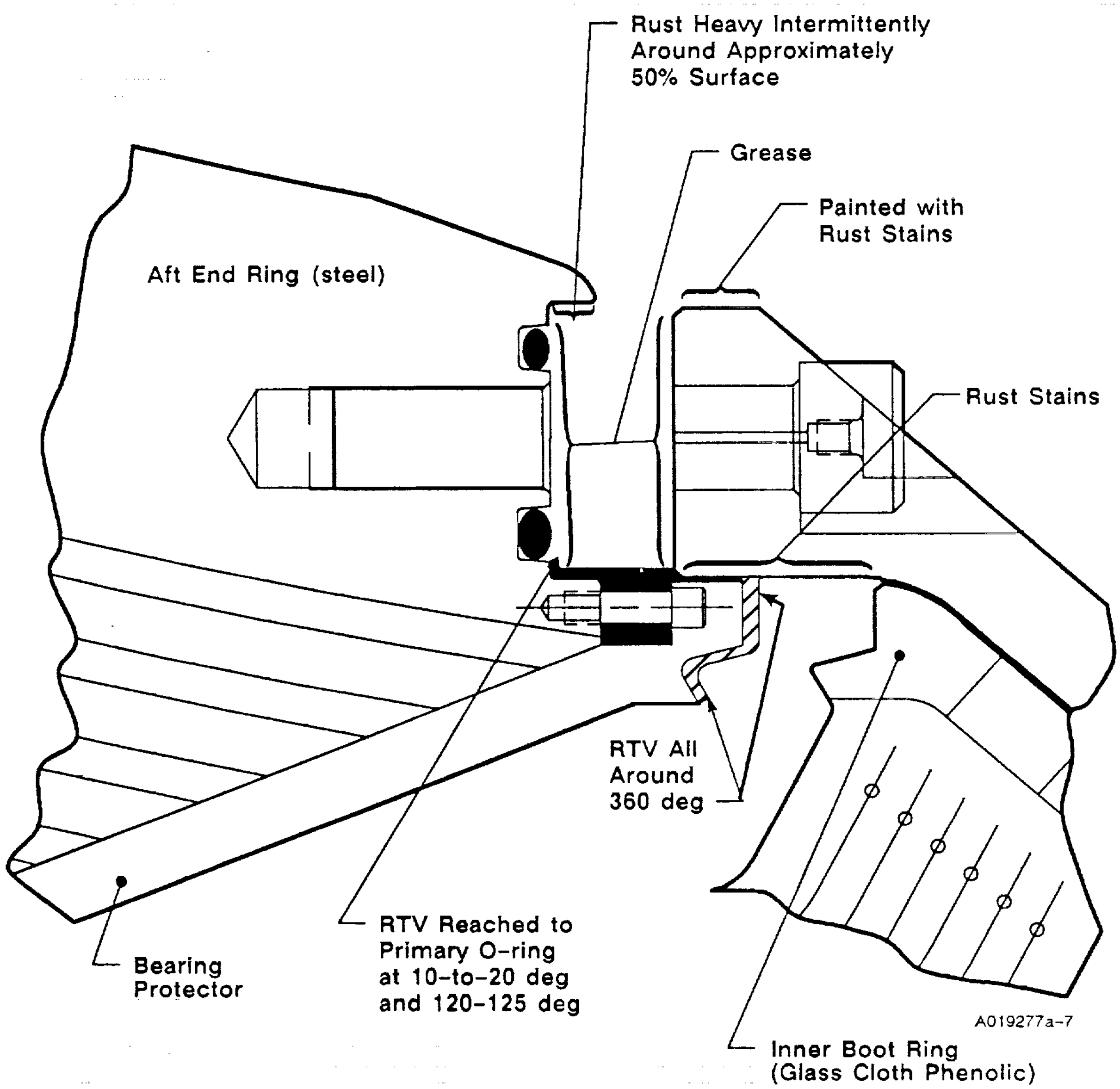

Figure 89 STS-28A Flex Bearing/Fixed Housing Joint (Joint #5)

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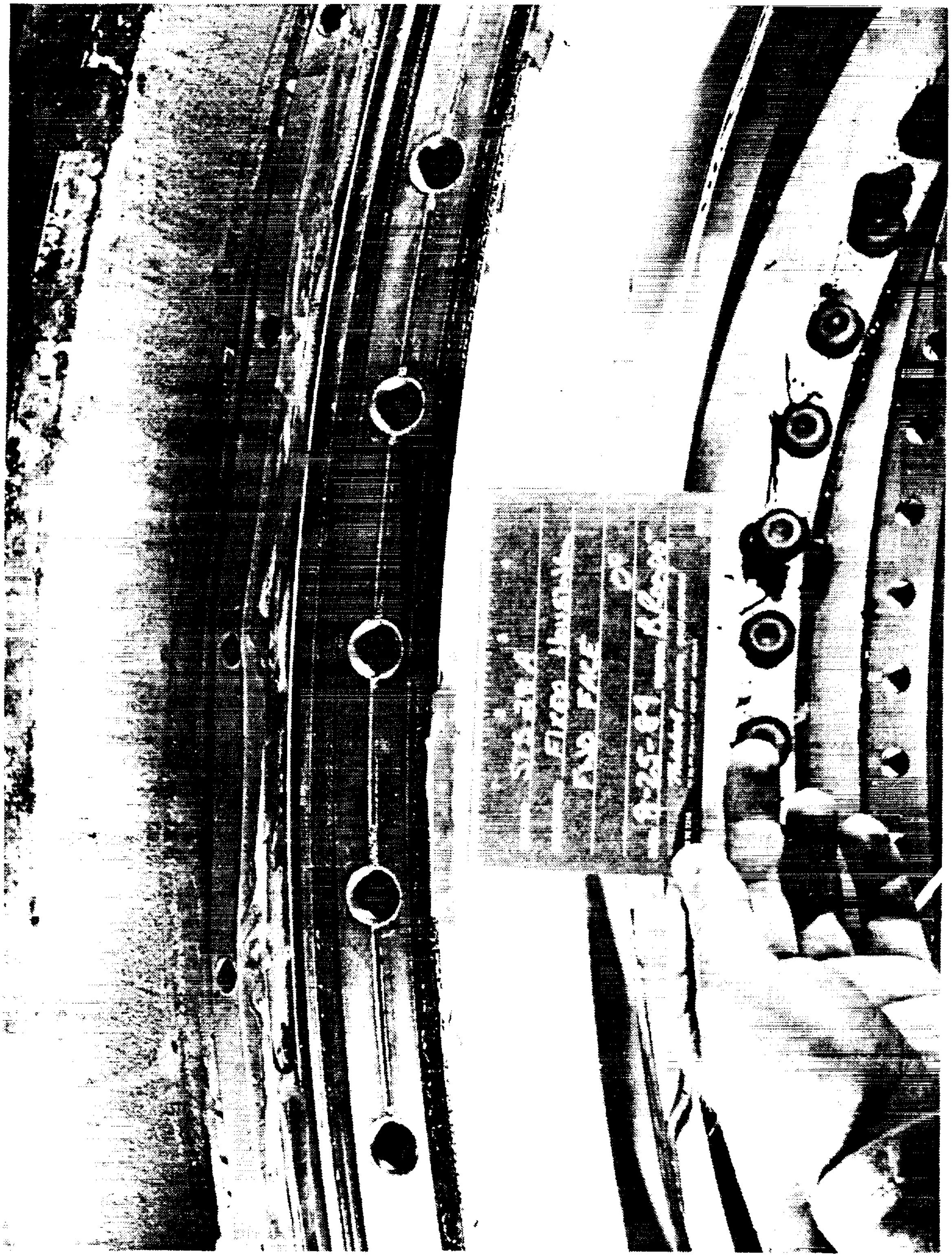

Figure 90 STS-28A Fixed Housing Forward End (0 deg)

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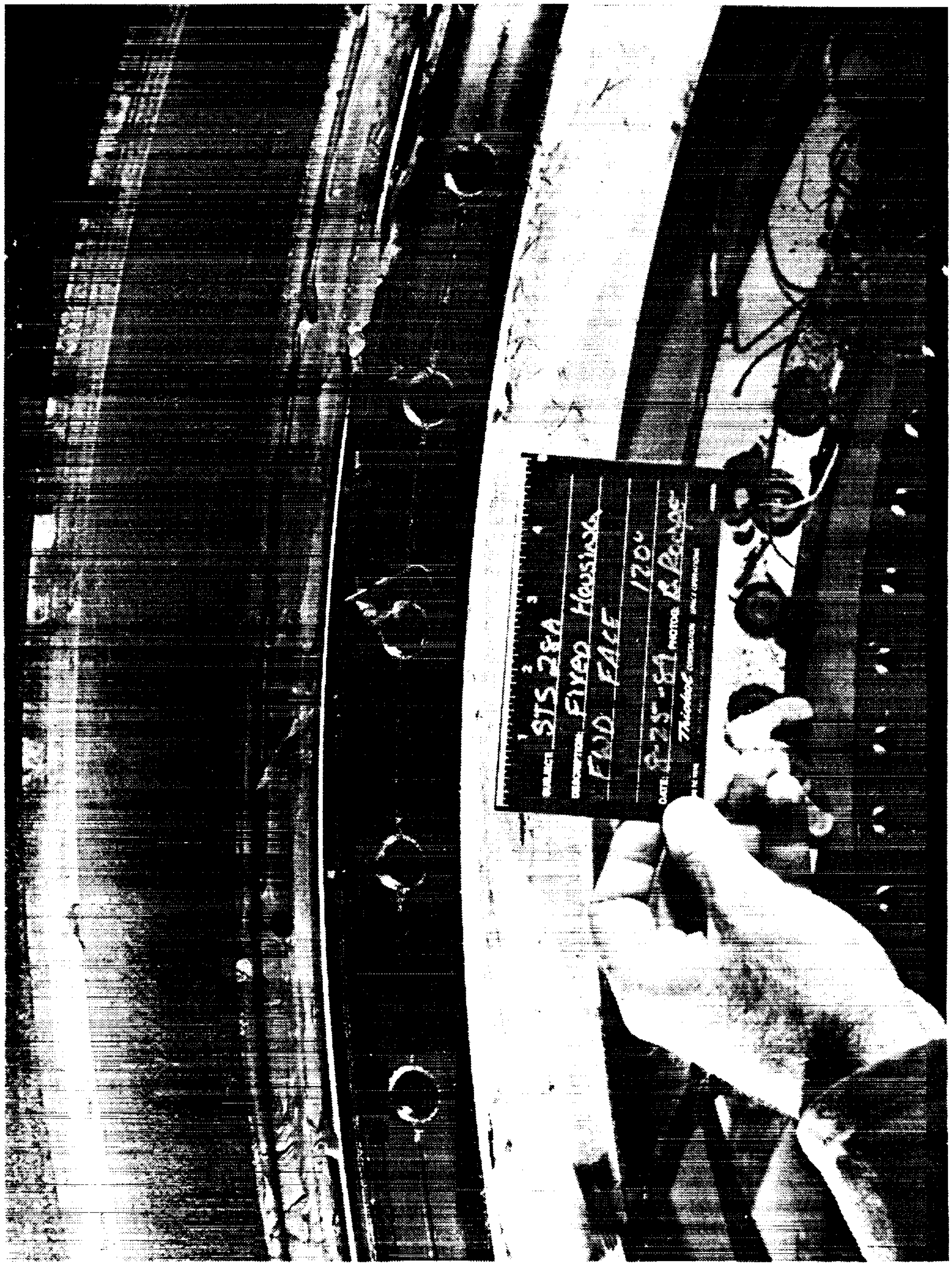

Figure 91 STS-28A Fixed Housing Forward End (120 deg)

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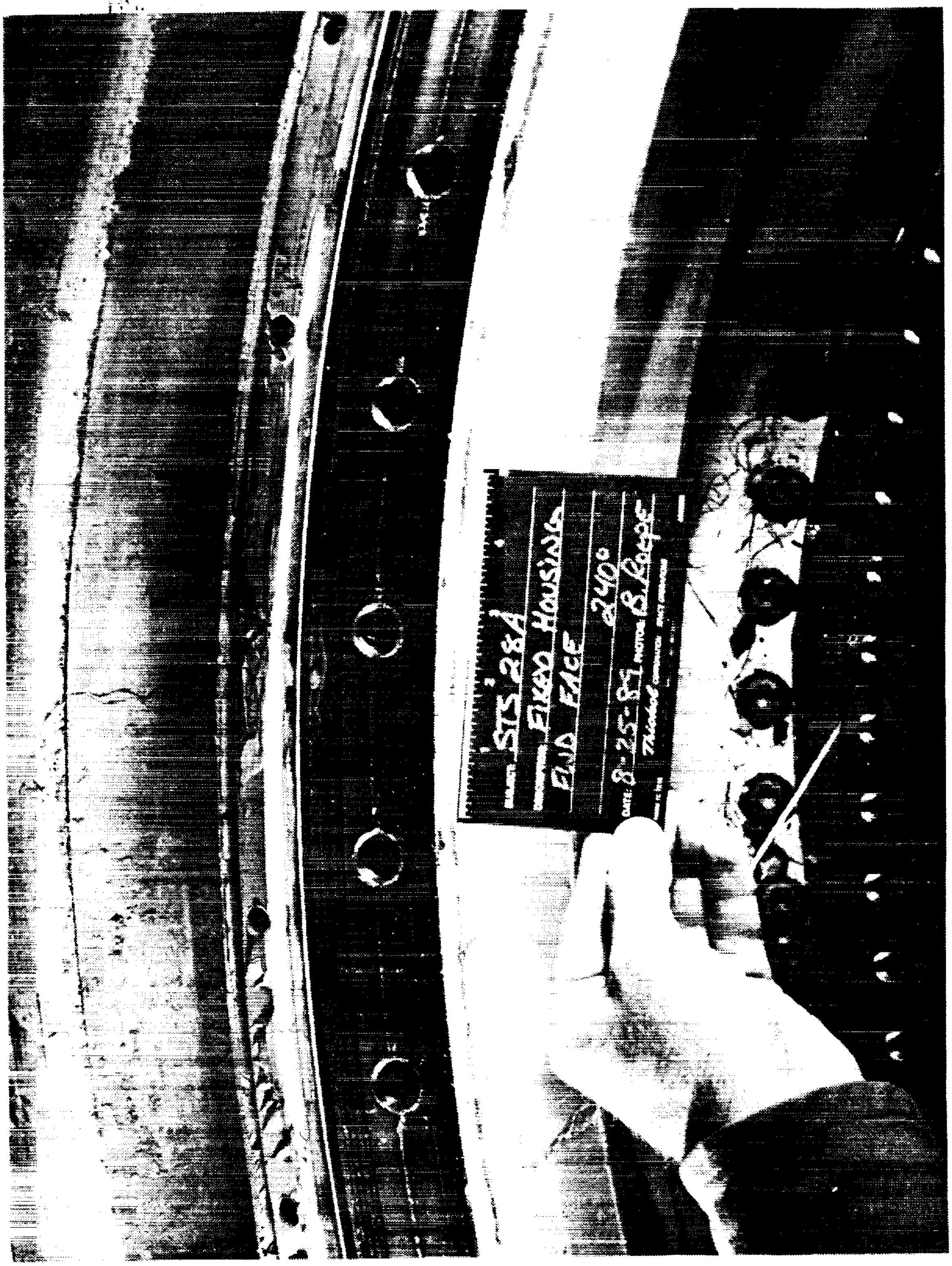

Figure 92. STS-28A Fixed Housing Forward End (240 deg)

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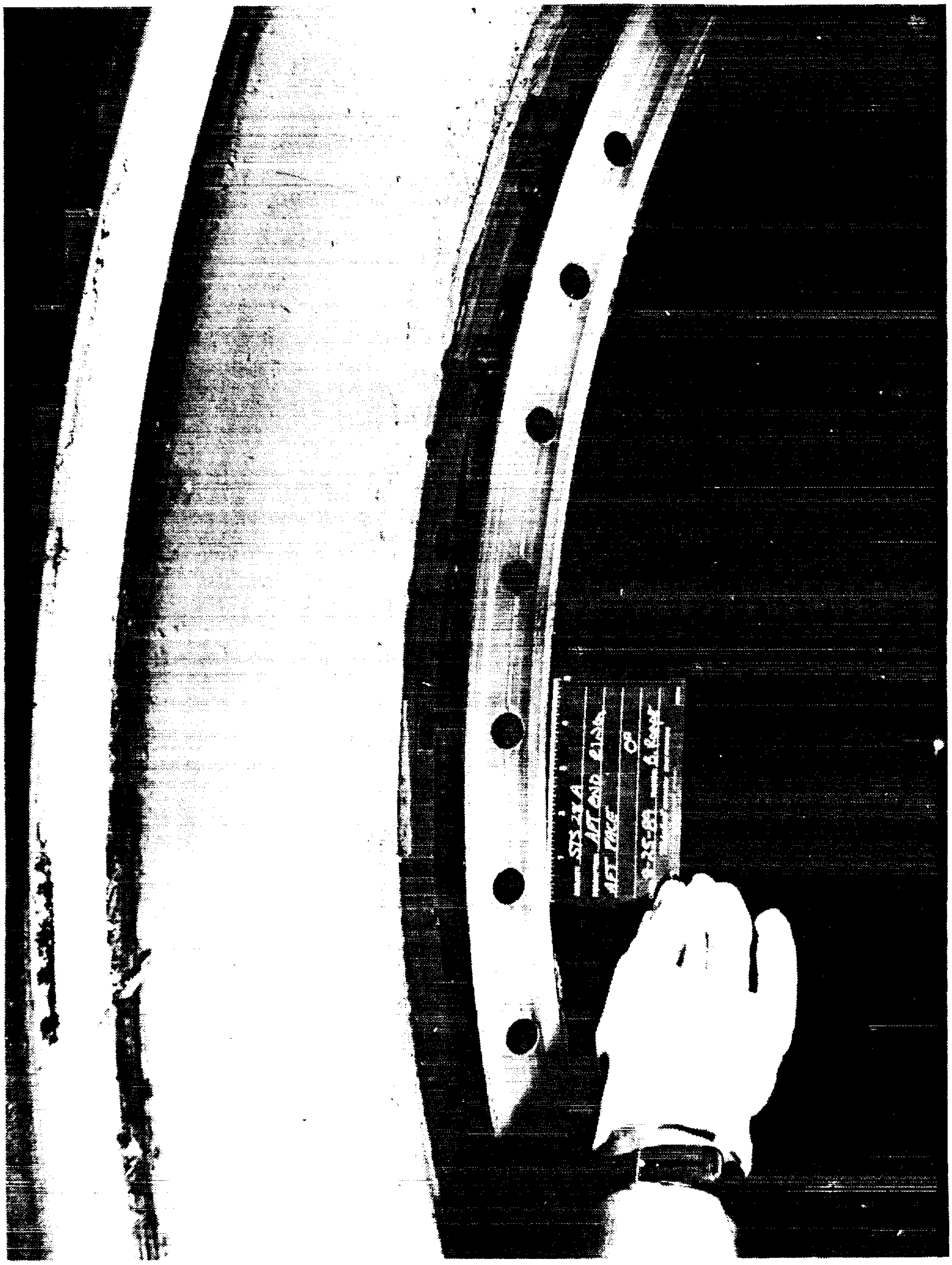

Figure 93 STS-28A Bearing Aft End Ring (0 deg)

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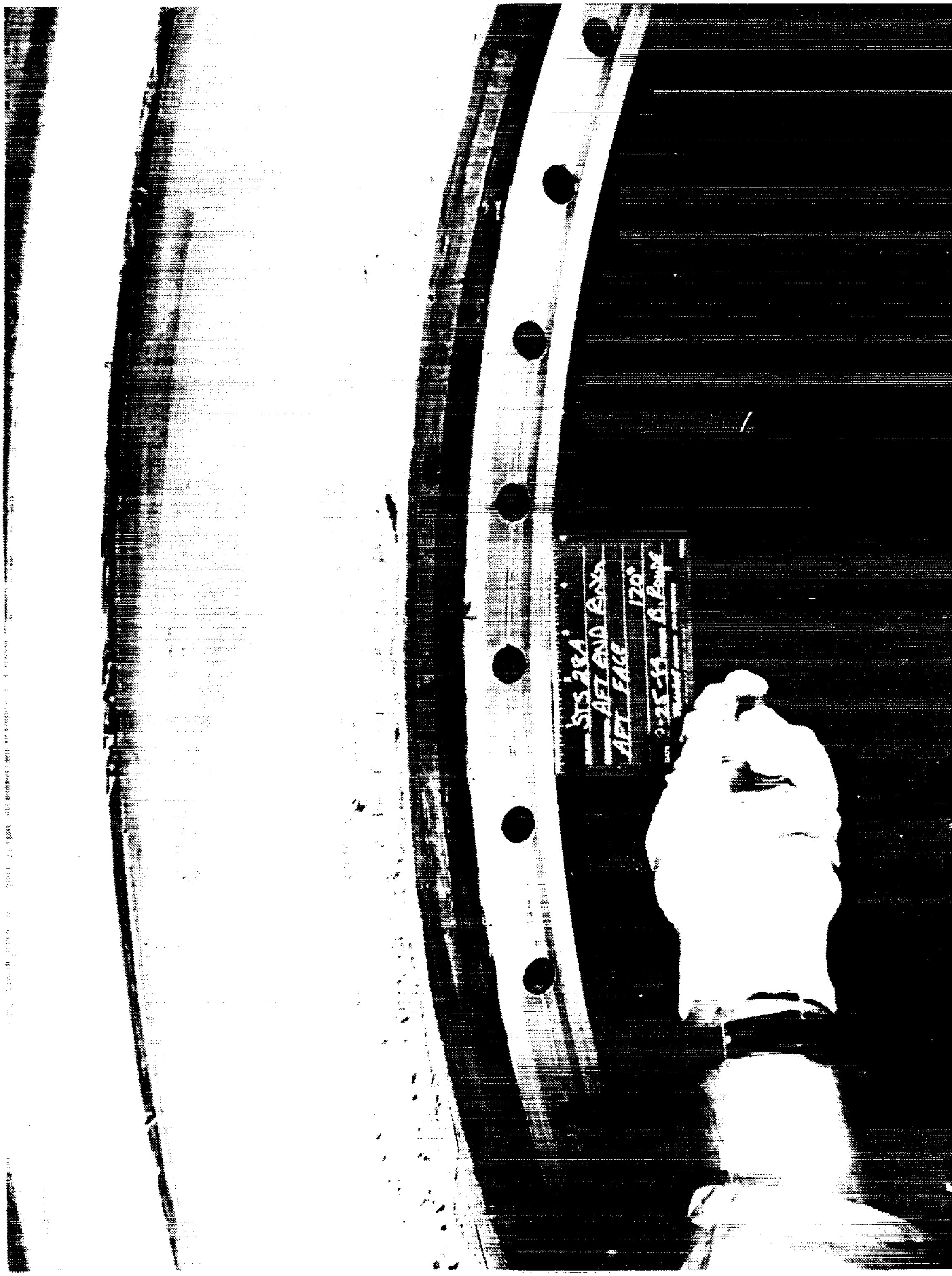

Figure 94 STS-28A Bearing Aft End Ring (120 deg)

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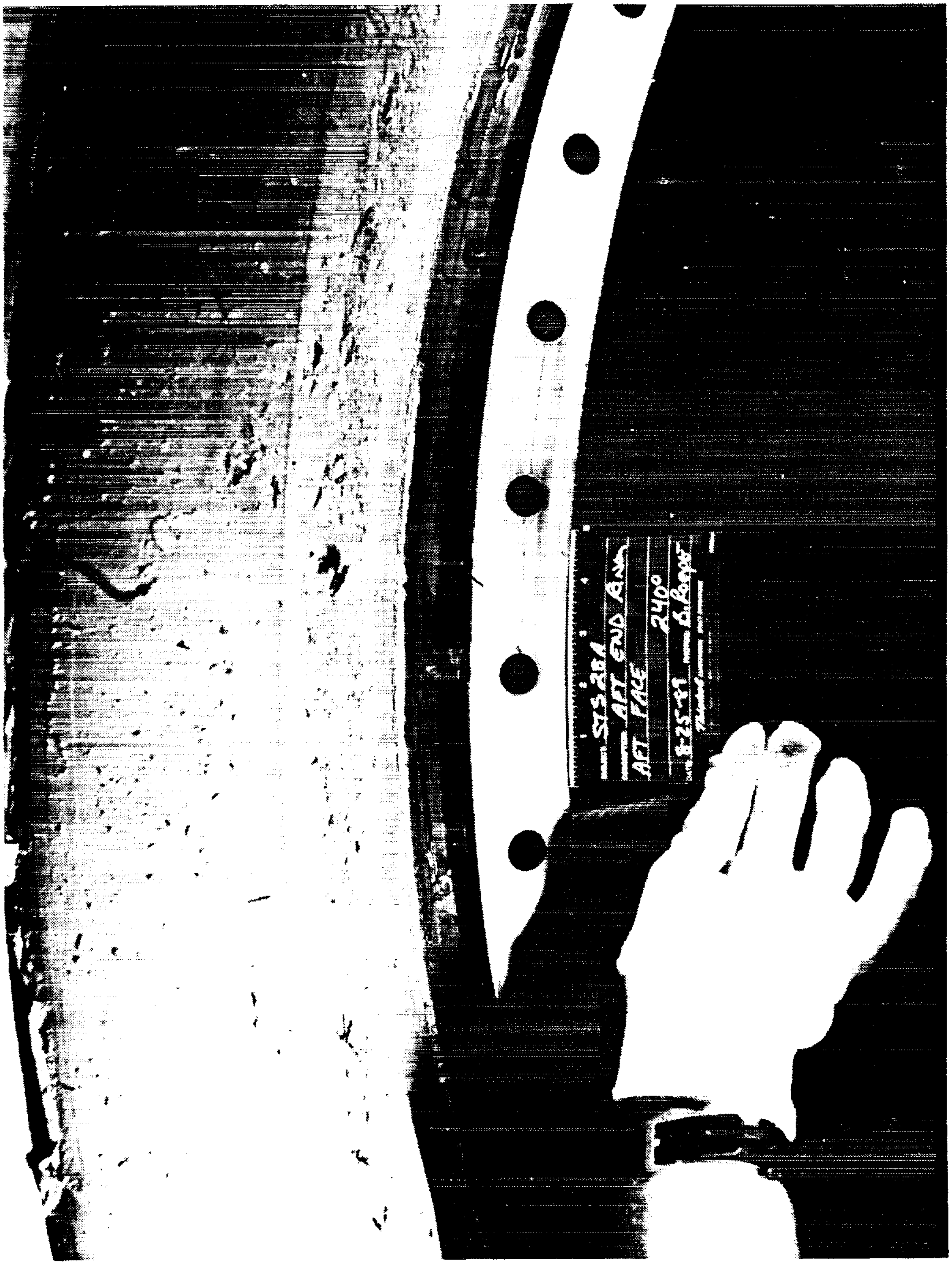

Figure 95 STS-28A Bearing Aft End Ring (240 deg)

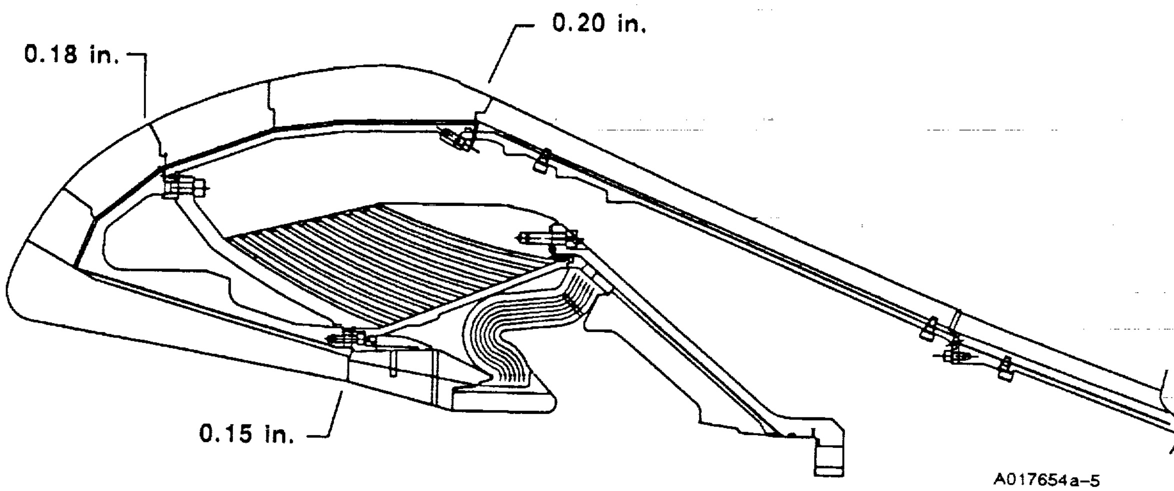

Figure 96 STS-28B Joint Flow Surface Gap Openings

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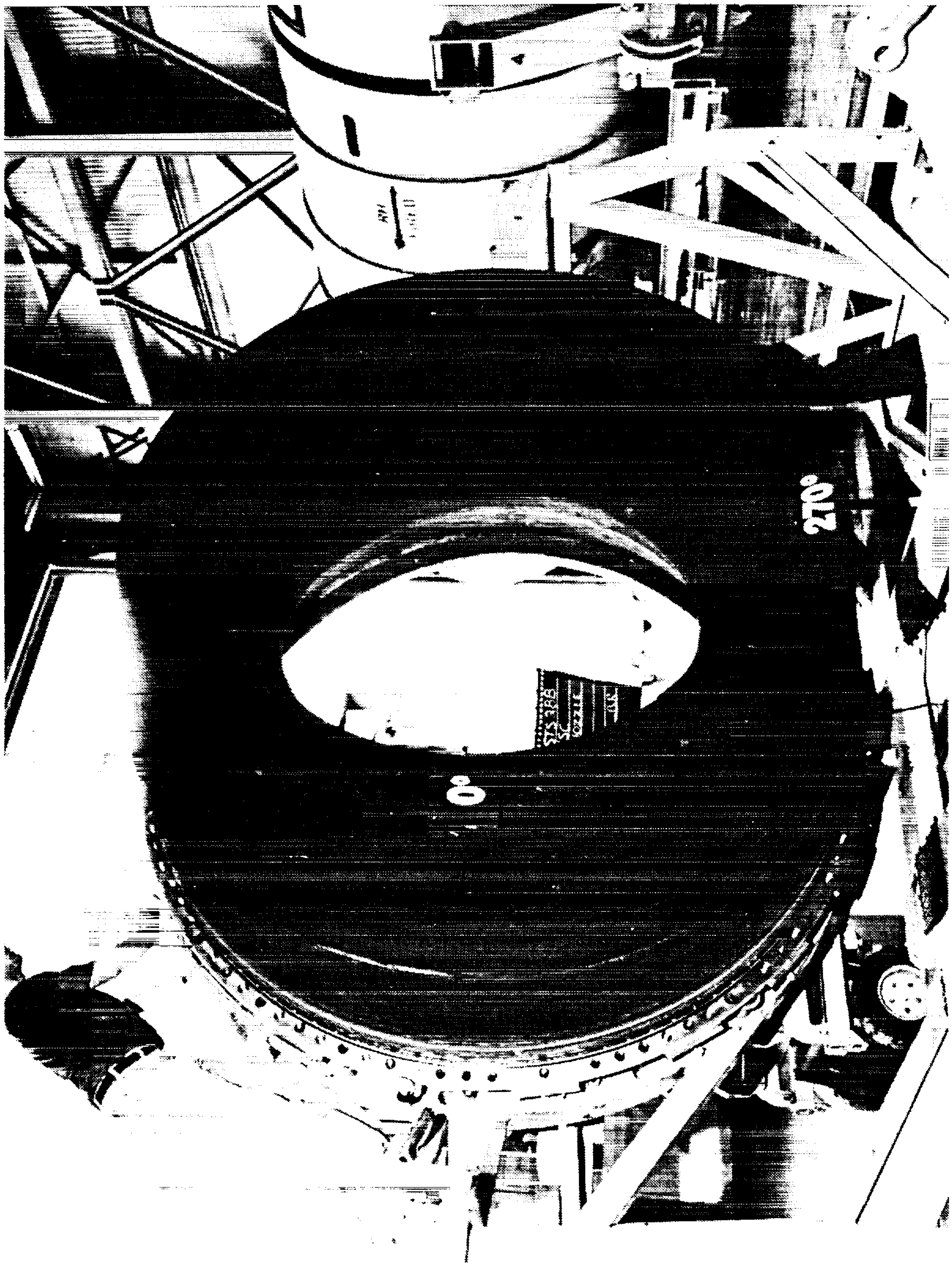

Figure 97 STS-28B Forward Nozzle Assembly

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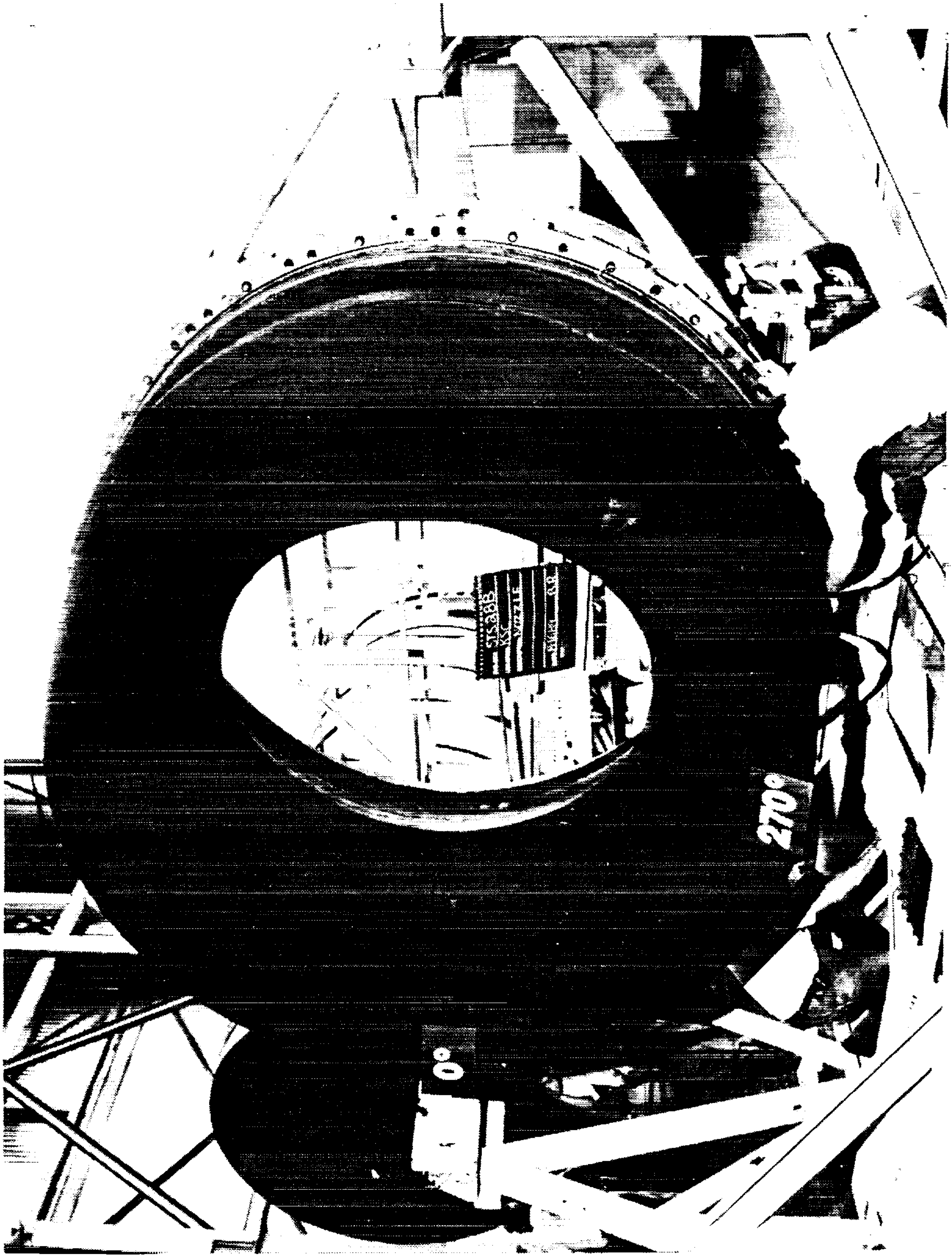

Figure 98 STS-28B Forward Nozzle Assembly

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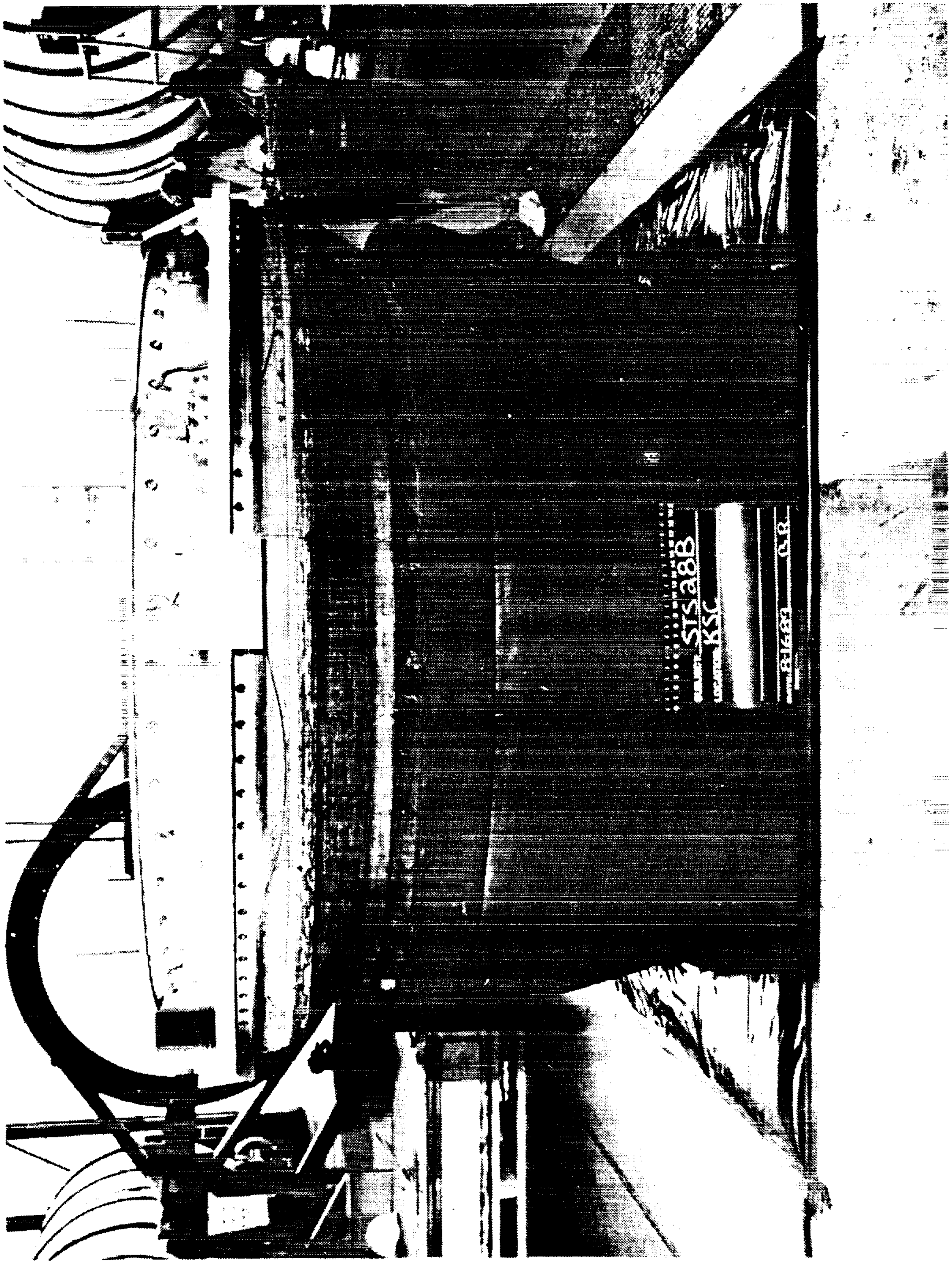

Figure 99 STS-28B Forward Nozzle Assembly (External)

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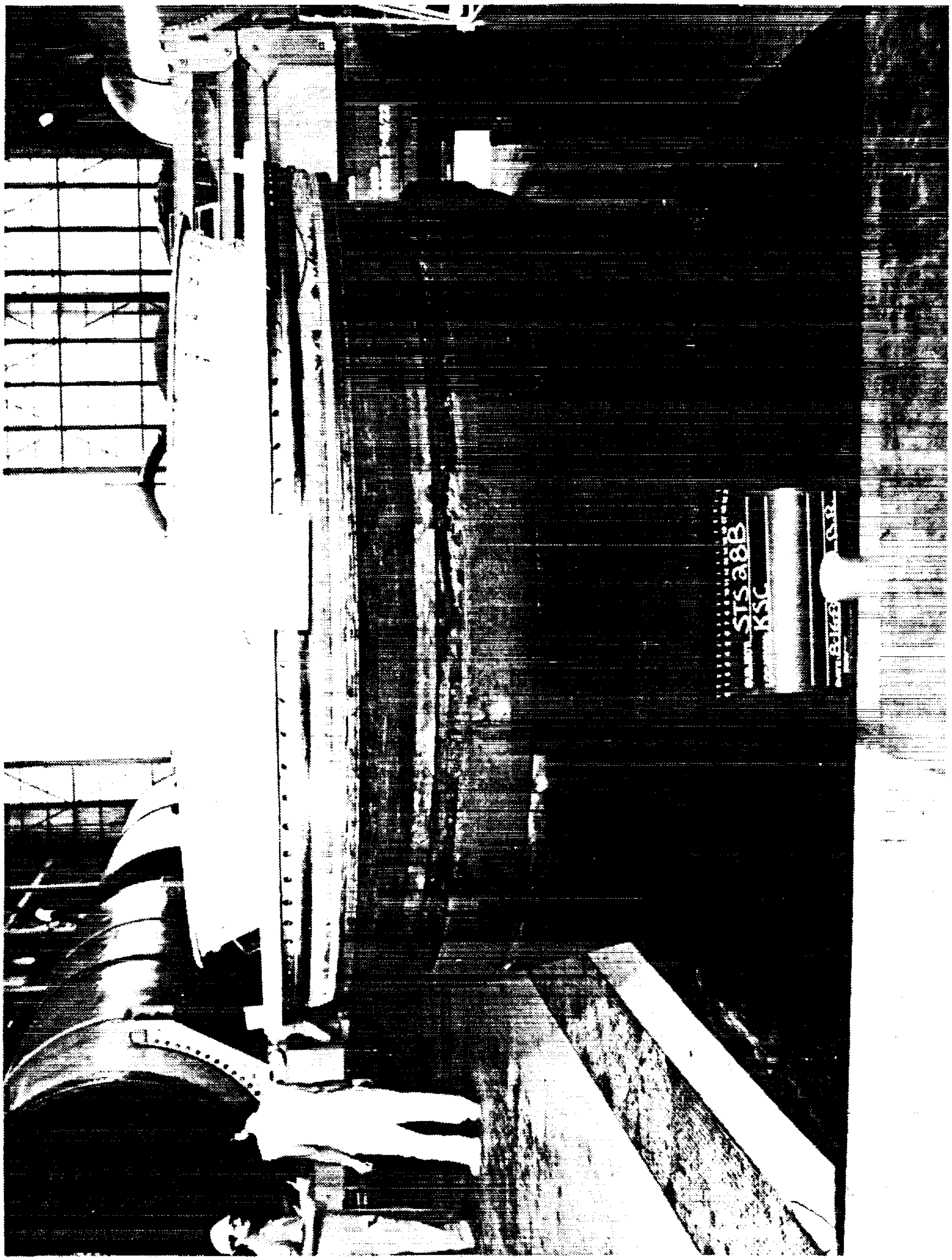

Figure 100 STS-28B Forward Nozzle Assembly (External)

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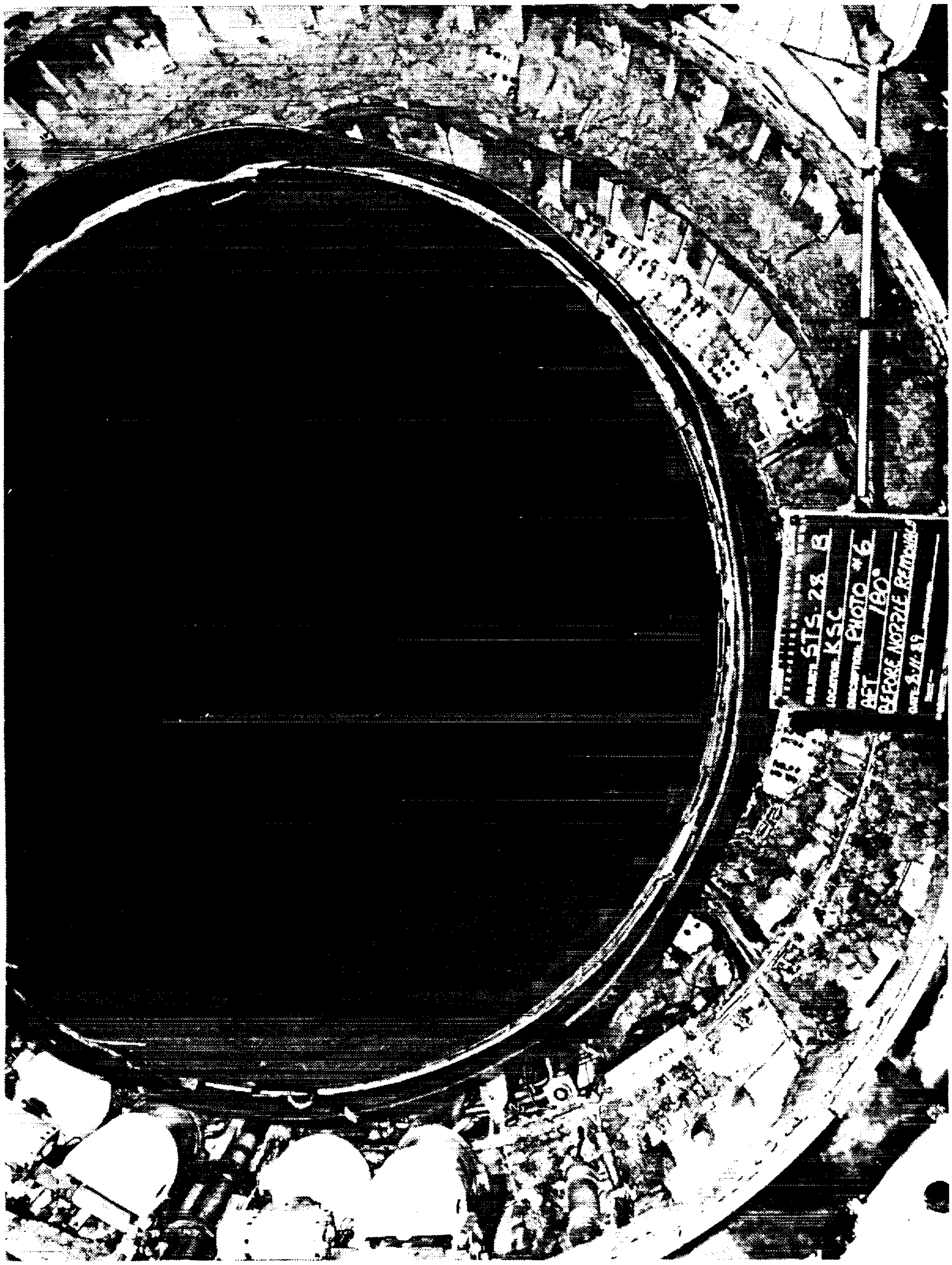

Figure 101 STS-28B Aft Exit Cone Fragment

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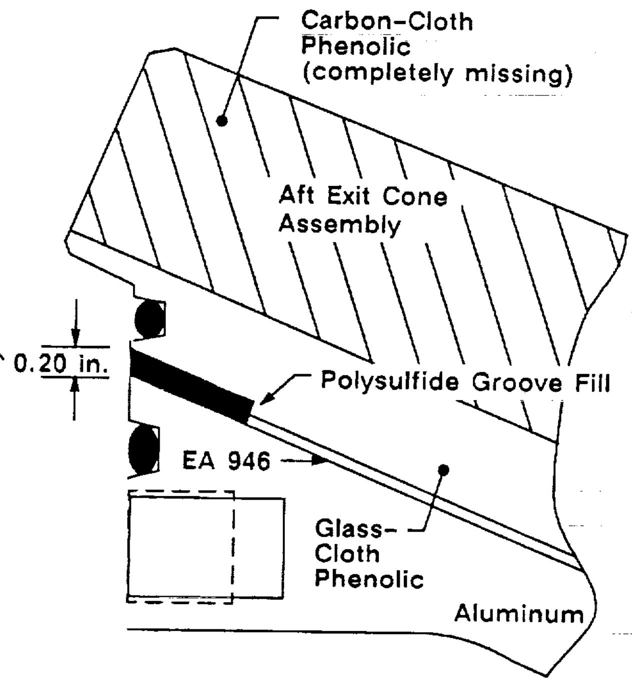
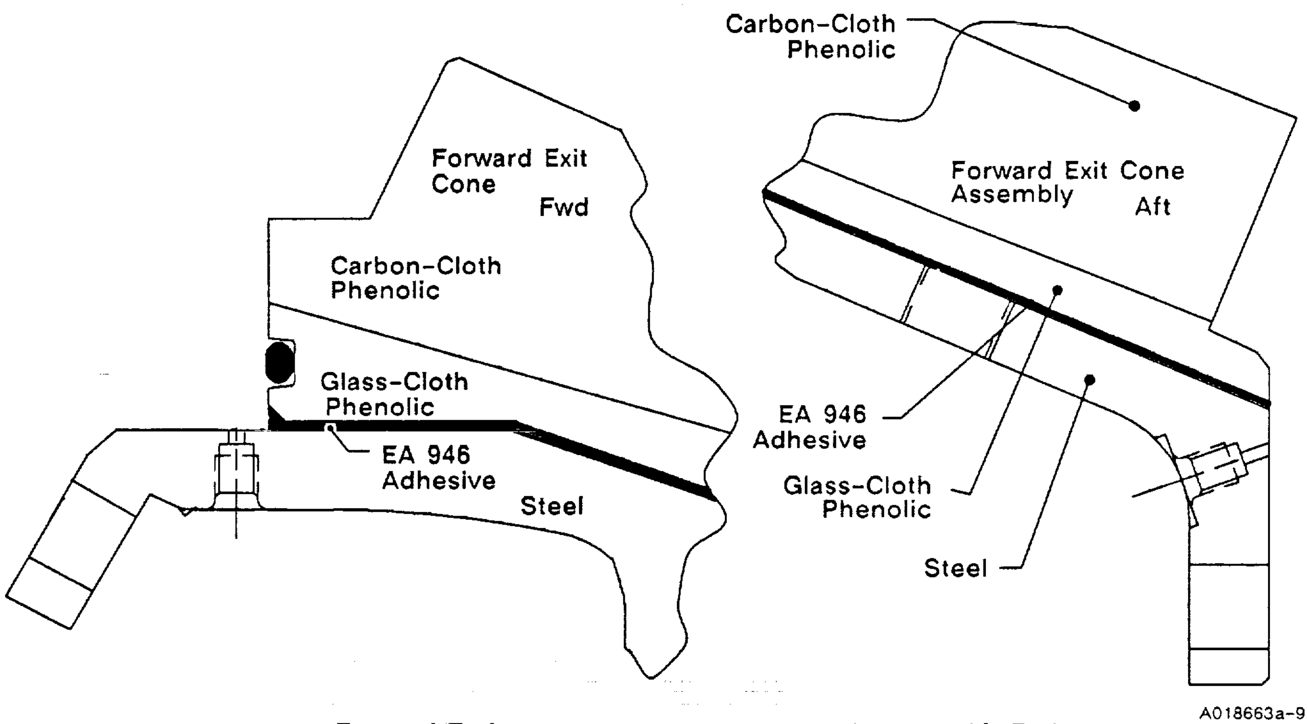
Table 9 STS-28B Aft Exit Cone Post-Flight Polysulfide Groove Radial Widths



Angular Location (deg)	Width (in.)
0	0.18
30	0.18
60	0.18
90	0.18
120	0.18
150	0.18
180	0.19
210	0.18
240	0.18
270	0.18
300	0.18
330	0.18



Forward End

Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
360 Circumferentially	0.020

Aft End

Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
0	0.020
30-45	0.010
60-75	0.020
105-135	0.010
150	0.020
285	0.010
300	0.020
330	0.005

Figure 102 STS-28B Forward Exit Cone Bondline Separations

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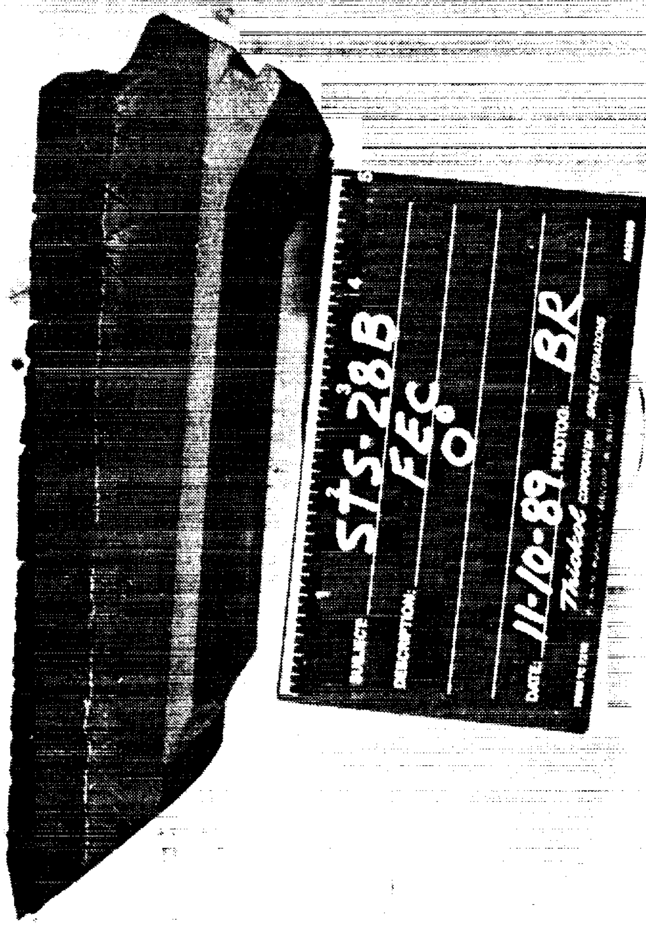

Figure 103 STS-28B Forward Exit Cone Liner Section (0 deg)

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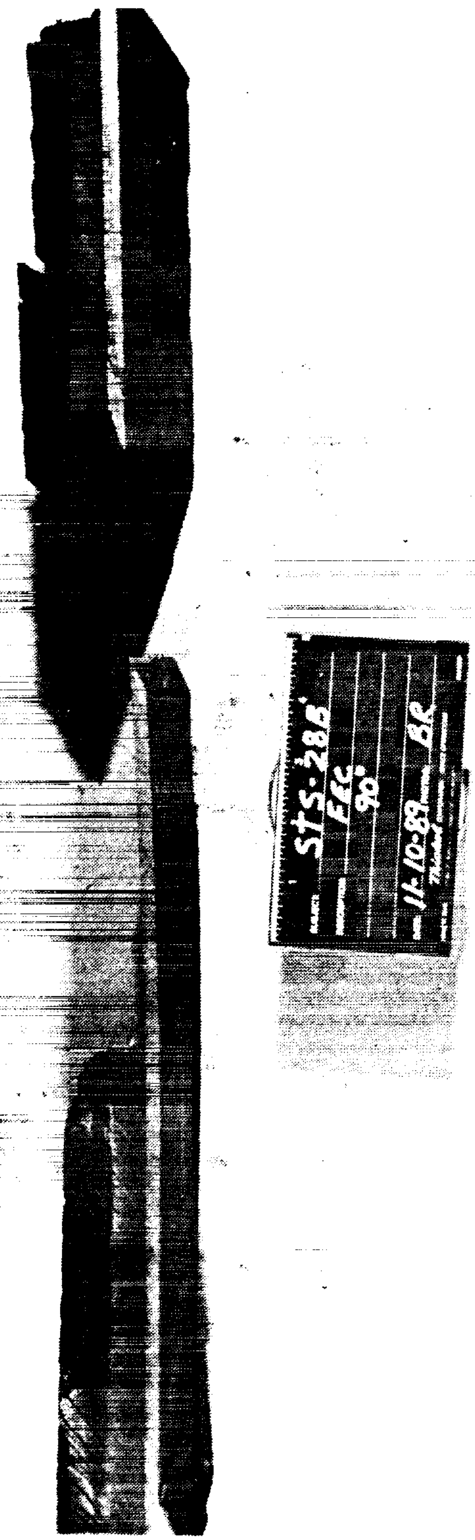

Figure 104 STS-28B Forward Exit Cone Liner Section (90 deg)

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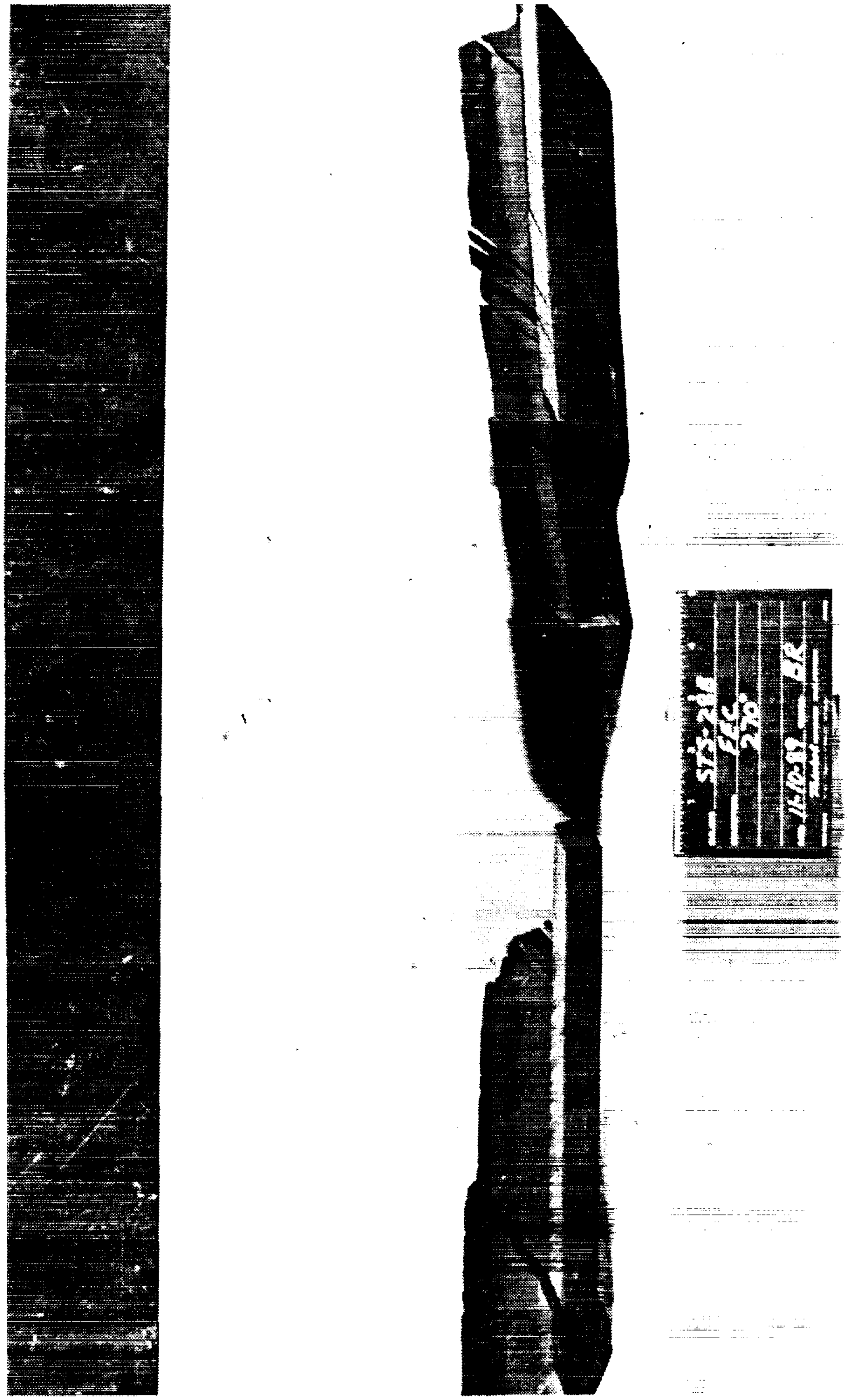


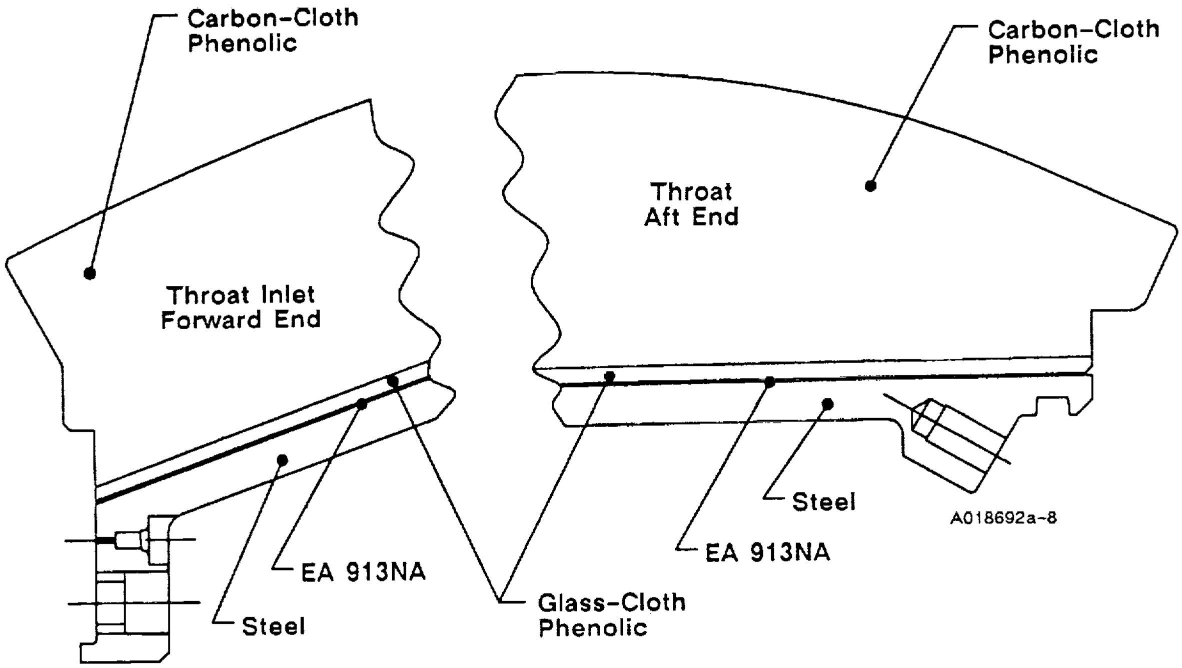
Figure 105 STS-28B Forward Exit Cone Liner Section (270 deg)

Table 10 STS-28B Forward Exit Cone Erosion and Char Data

Angular Location	Stations									
	1	4	8	12	16	20	24	28	32	34
0 degrees										
Measured Erosion	0.35	0.32	NA	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.68	0.73	NA	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.54	0.58	NA	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.38	1.37	NA	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.31	0.26	NA	NA	NA	NA	NA	NA	NA	NA
90 degrees										
Measured Erosion	0.35	0.33	NA	NA	NA	NA	NA	0.29	0.19	0.18
Measured Char	0.79	0.81	NA	NA	NA	NA	NA	0.70	0.70	0.71
Adjusted Char*	0.63	0.65	NA	NA	NA	NA	NA	0.56	0.56	0.57
2E + 1.25AC	1.49	1.47	NA	NA	NA	NA	NA	1.28	1.08	1.07
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.21	0.18	NA	NA	NA	NA	NA	0.04	0.27	0.32
180 degrees										
Measured Erosion	0.34	0.33	0.33	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.71	0.73	0.72	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.57	0.58	0.58	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.39	1.39	1.38	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.30	0.25	0.18	NA	NA	NA	NA	NA	NA	NA
270 degrees										
Measured Erosion	0.32	0.41	NA	NA	NA	NA	NA	0.30	0.19	0.16
Measured Char	0.88	0.76	NA	NA	NA	NA	NA	0.66	0.61	0.67
Adjusted Char*	0.70	0.61	NA	NA	NA	NA	NA	0.53	0.49	0.54
2E + 1.25AC	1.52	1.58	NA	NA	NA	NA	NA	1.26	0.99	0.99
RSRM Min Liner Thickness	1.807	1.731	1.629	1.524	1.426	1.356	1.322	1.328	1.372	1.408
Margin of Safety	0.19	0.10	NA	NA	NA	NA	NA	0.05	0.39	0.42

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$



Fwd End Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separations (in.)
0-105	0.020
120-210	0.010
225-345	0.020

Aft End Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
360 Circumferentially	0.035

Figure 106 STS-28B Throat Assembly Bondline Separations

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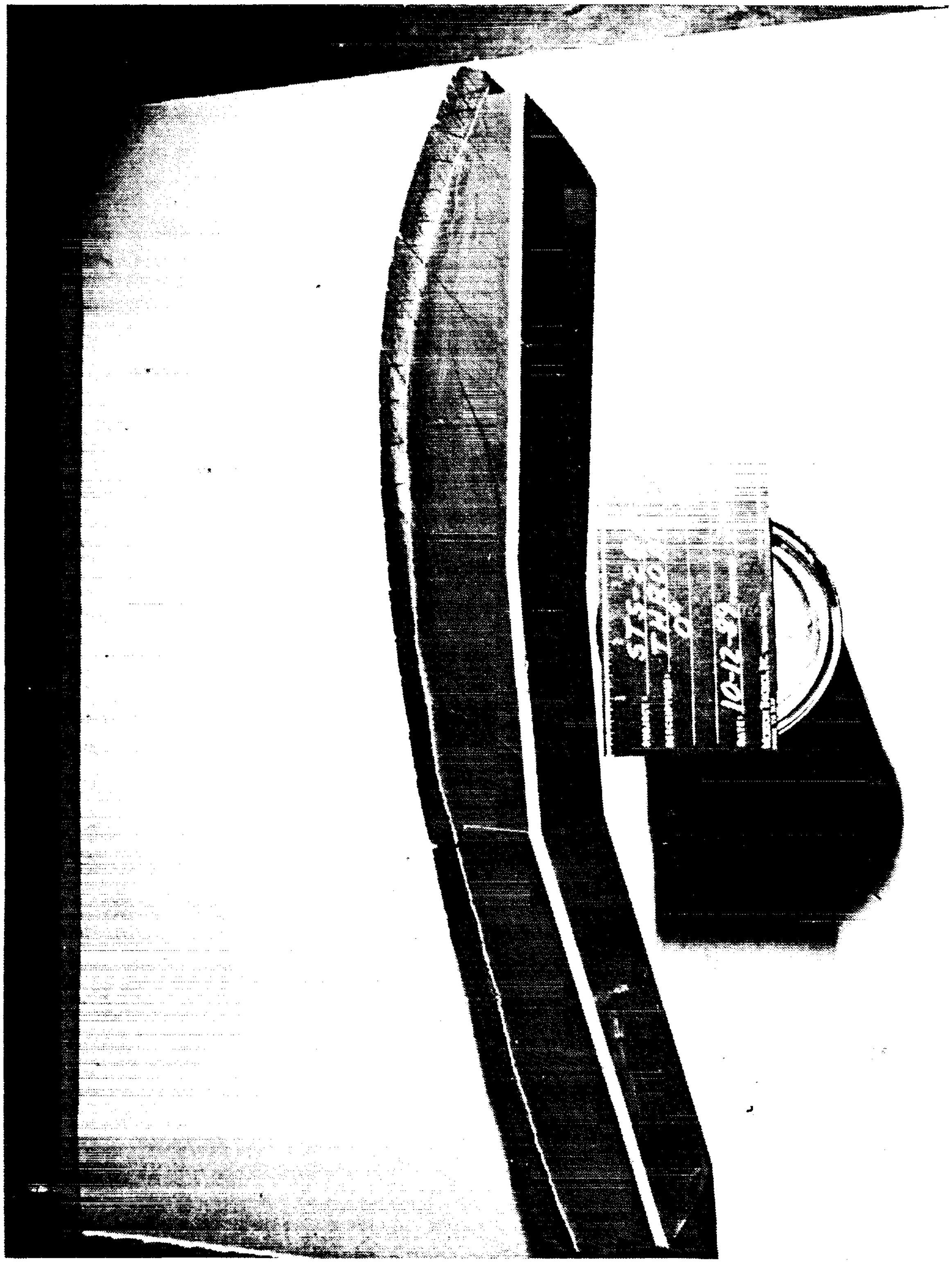

Figure 107 STS-28B Throat/Throat Inlet Section (0 deg)

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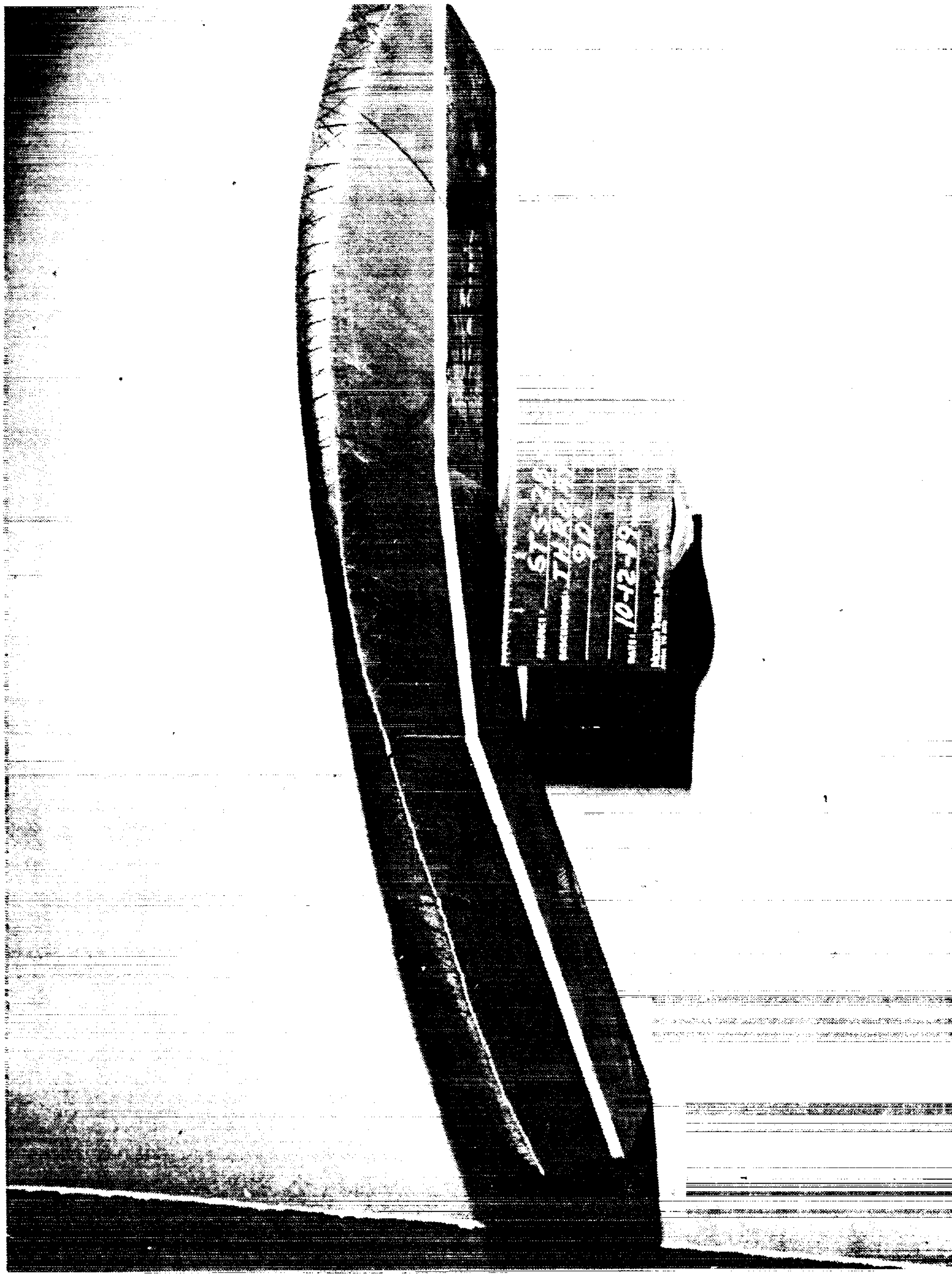

Figure 108 STS-28B Throat/Throat Inlet Section (90 deg)

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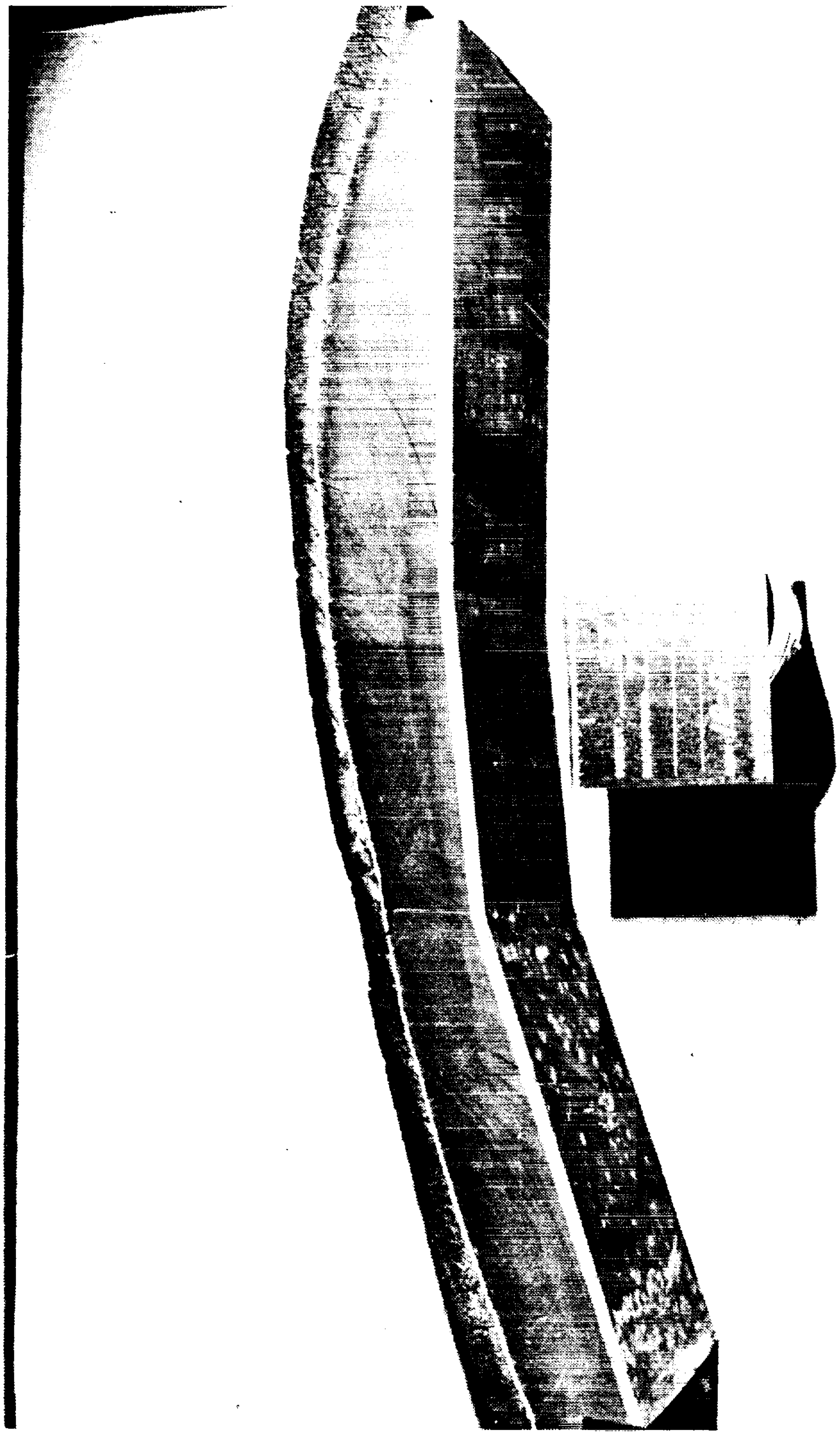

Figure 109 STS-28B Throat/Throat Inlet Section (180 deg)

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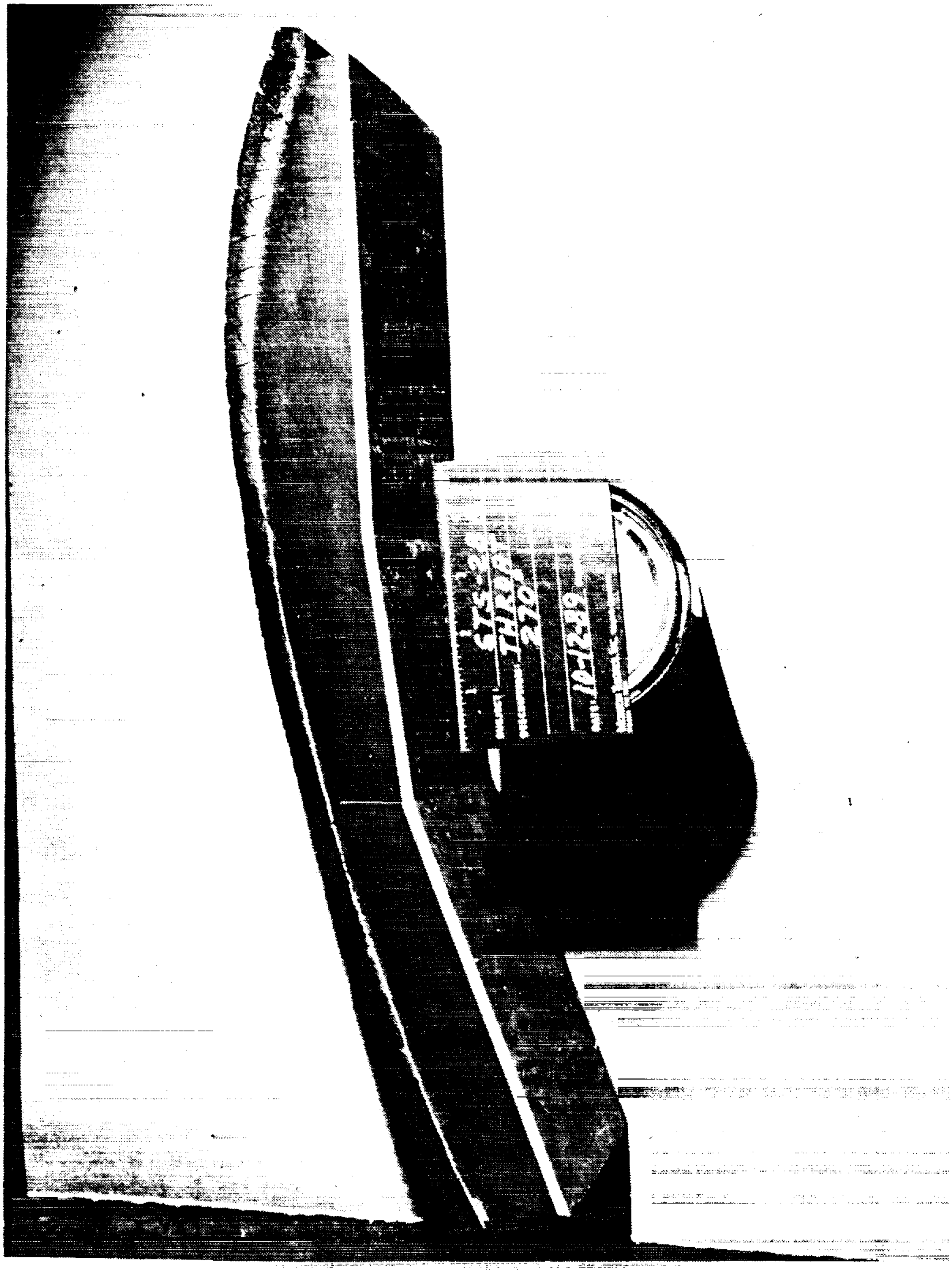

Figure 110 STS-28B Throat/Throat Inlet Section (270 deg)

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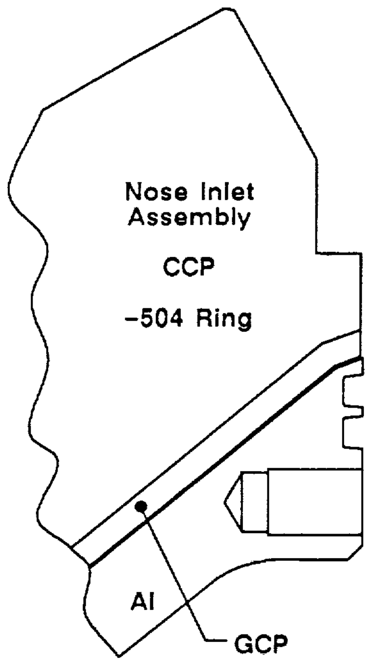
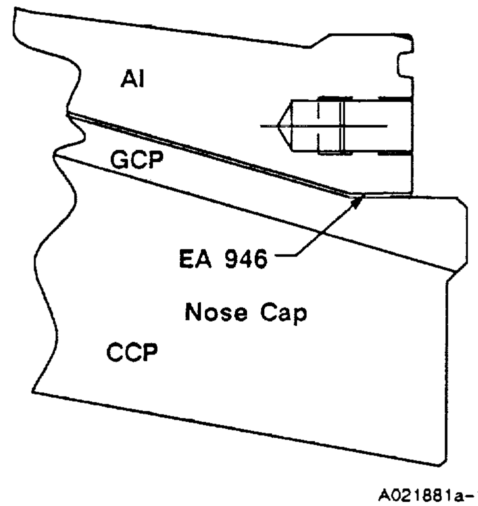
Table 11 STS-28B Throat Assembly Erosion and Char Data

Angular Location	Stations												
0 degrees	1	2	4	6	8	10	12	14	16	18	20	22	23
Measured Erosion	1.07	1.11	1.15	1.17	1.28	1.17	1.15	1.12	1.05	0.89	0.66	0.44	0.37
Measured Char	0.52	0.52	0.59	0.64	0.44	0.49	0.46	0.54	0.55	0.61	0.71	0.75	0.83
Adjusted Char *	0.39	0.39	0.44	0.48	0.33	0.37	0.35	0.41	0.41	0.46	0.53	0.56	0.62
2E + 1.25AC	2.63	2.71	2.85	2.94	2.97	2.80	2.73	2.75	2.62	2.35	1.99	1.58	1.52
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	2.231	2.583	2.110
Margin of Safety	0.21	0.20	0.16	0.12	0.07	0.21	0.29	0.32	0.42	0.52	0.12	0.63	0.39
90 degrees													
Measured Erosion	1.08	1.13	1.14	1.17	1.29	1.21	1.18	1.14	1.06	0.88	0.69	0.45	0.40
Measured Char	0.70	0.65	0.71	0.68	0.48	0.43	0.45	0.59	0.63	0.73	0.75	0.80	0.80
Adjusted Char *	0.53	0.49	0.53	0.51	0.36	0.32	0.34	0.44	0.47	0.55	0.56	0.60	0.60
2E + 1.25AC	2.82	2.87	2.95	2.98	3.03	2.82	2.78	2.83	2.71	2.44	2.08	1.65	1.55
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	2.231	2.583	2.110
Margin of Safety	0.13	0.13	0.13	0.10	0.05	0.20	0.26	0.28	0.37	0.47	0.07	0.57	0.36
180 degrees													
Measured Erosion	1.10	1.10	1.17	1.19	1.27	1.22	1.15	1.13	1.06	0.92	0.70	0.47	0.40
Measured Char	0.69	0.71	0.68	0.65	0.53	0.53	0.52	0.53	0.61	0.73	0.75	0.81	0.84
Adjusted Char *	0.52	0.53	0.51	0.49	0.40	0.40	0.39	0.40	0.46	0.55	0.56	0.61	0.63
2E + 1.25AC	2.85	2.87	2.98	2.99	3.04	2.94	2.79	2.76	2.69	2.52	2.10	1.70	1.59
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	3.231	2.583	2.110
Margin of Safety	0.11	0.13	0.11	0.10	0.05	0.16	0.26	0.32	0.38	0.42	0.54	0.52	0.33
270 degrees													
Measured Erosion	1.07	1.12	1.14	1.22	1.29	1.16	1.15	1.14	1.06	0.89	0.69	0.45	0.36
Measured Char	0.57	0.57	0.64	0.55	0.42	0.52	0.52	0.51	0.55	0.59	0.71	0.75	0.82
Adjusted Char *	0.43	0.43	0.48	0.41	0.32	0.39	0.39	0.38	0.41	0.44	0.53	0.56	0.62
2E + 1.25AC	2.67	2.77	2.88	2.96	2.97	2.81	2.79	2.76	2.64	2.33	2.05	1.60	1.49
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.183	3.397	3.517	3.626	3.710	3.586	3.231	2.583	2.110
Margin of Safety	0.19	0.17	0.15	0.11	0.07	0.21	0.26	0.31	0.41	0.54	0.58	0.61	0.42

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$





Aft End
Metal-to-Adhesive
Bondline Separations

Location (deg)	Radial Separation (in.)
45-270	0.010

Figure 111 STS-28B Nose Inlet Assembly Bondline Separations

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Figure 112 STS-28B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (0 deg)

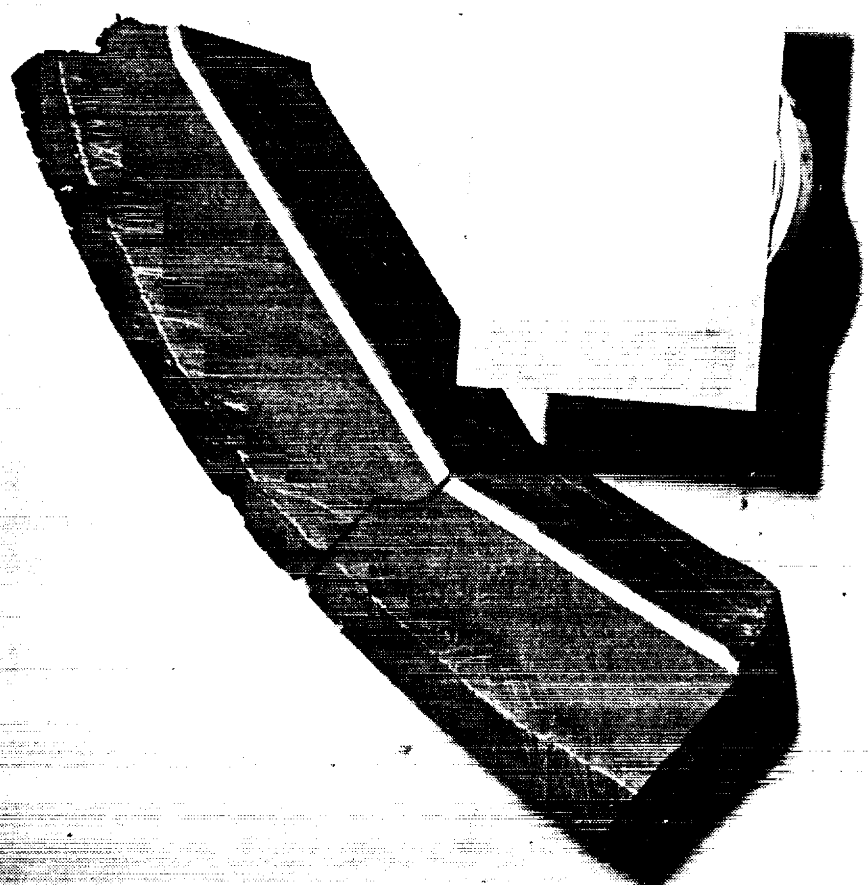

Figure 113 STS-28B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (90 deg)

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Figure 114 STS-28B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (180 deg)

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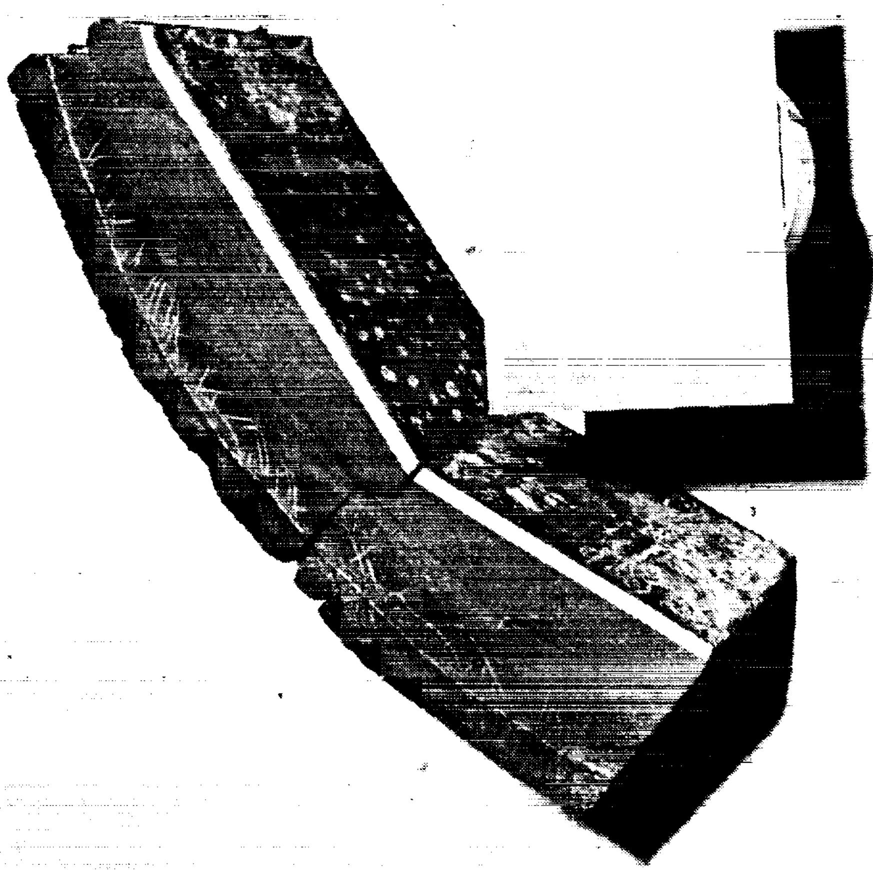

Figure 115 STS-28B Forward Nose Ring and Aft Inlet RIng (-503 and -504) Section (270 deg)

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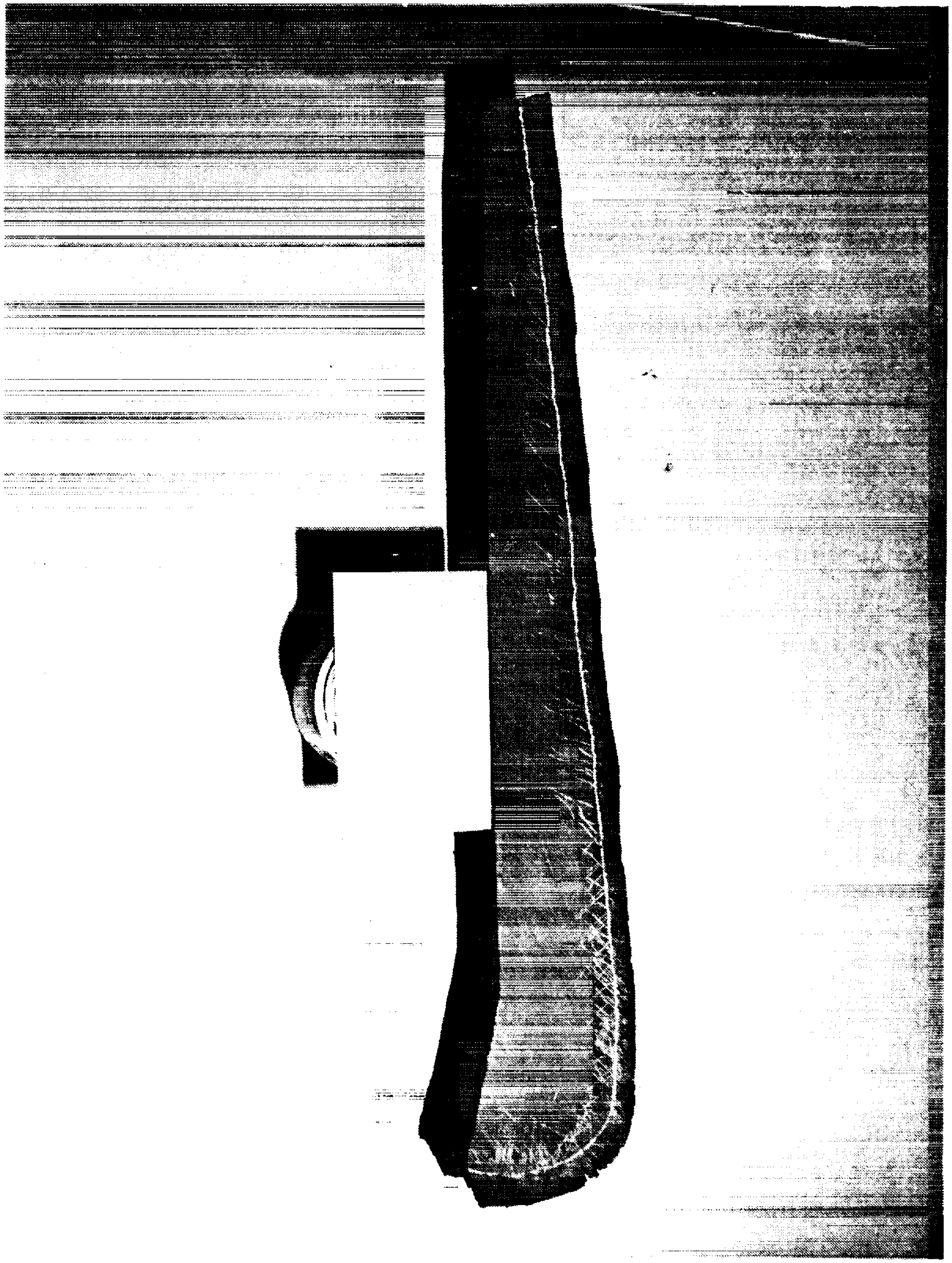

Figure 116 STS-28B Nose Cap Section (0 deg)

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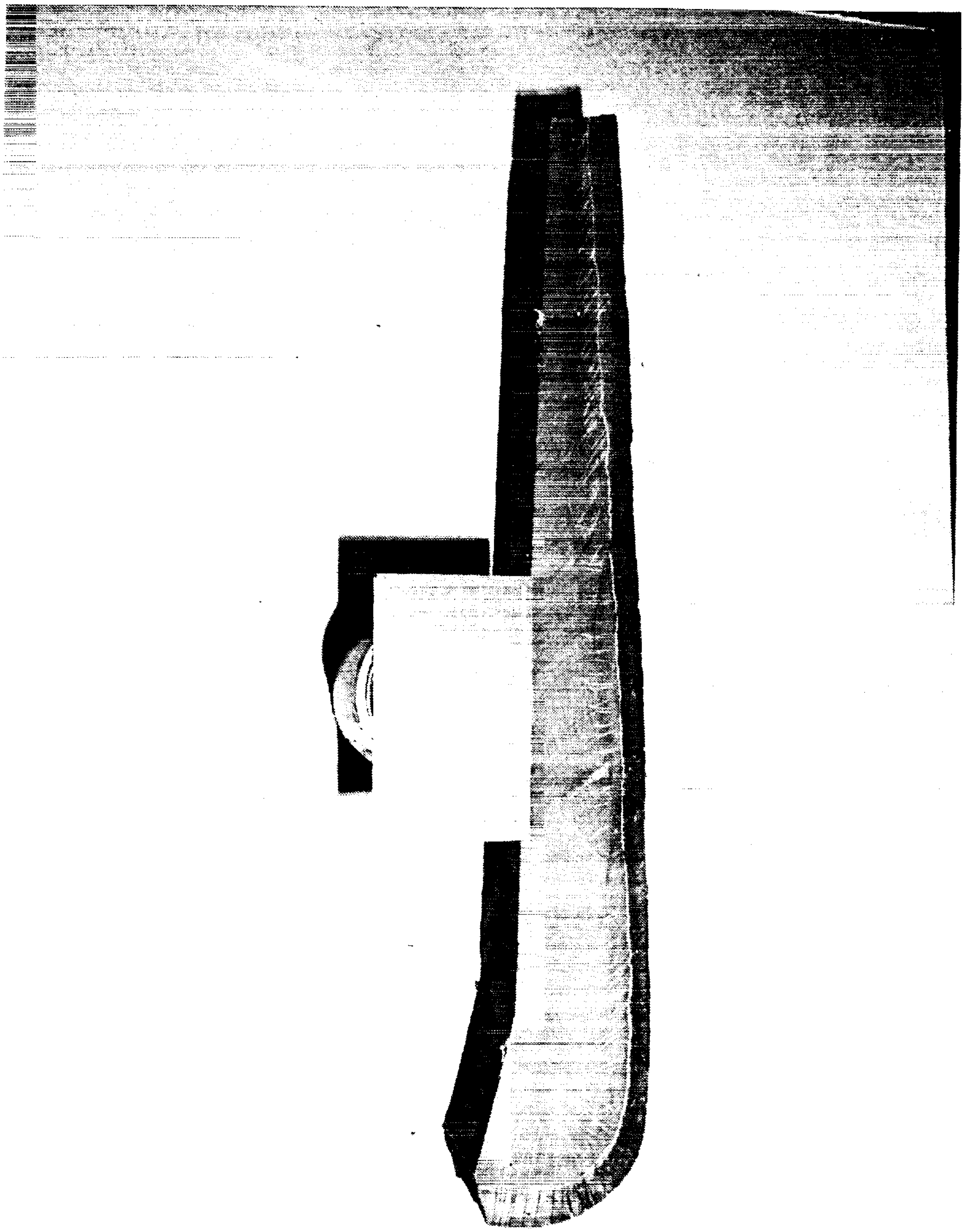

Figure 117 STS-28B Nose Cap Section (90 deg)

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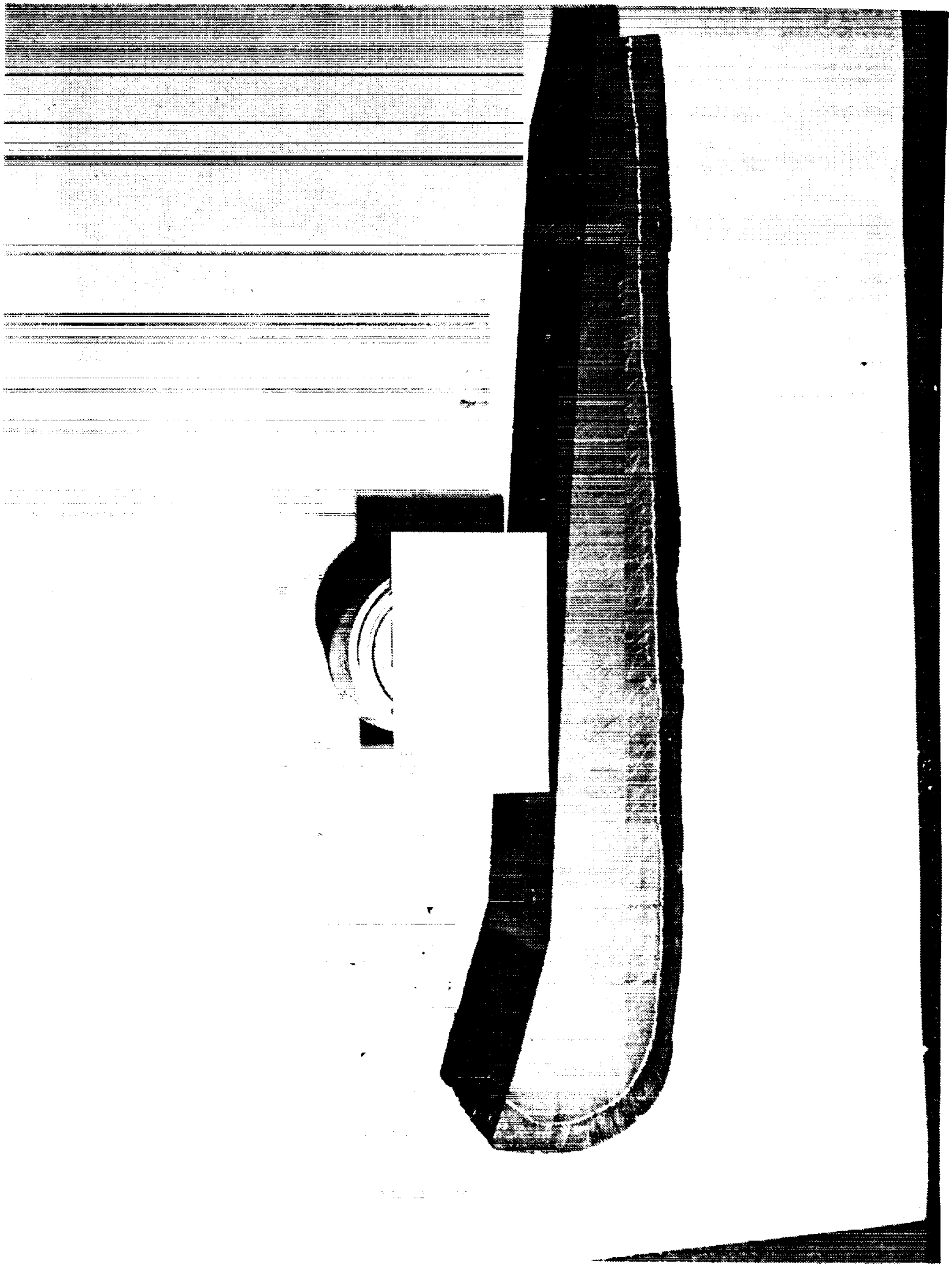

Figure 118 STS-28B Nose Cap Section (180 deg)

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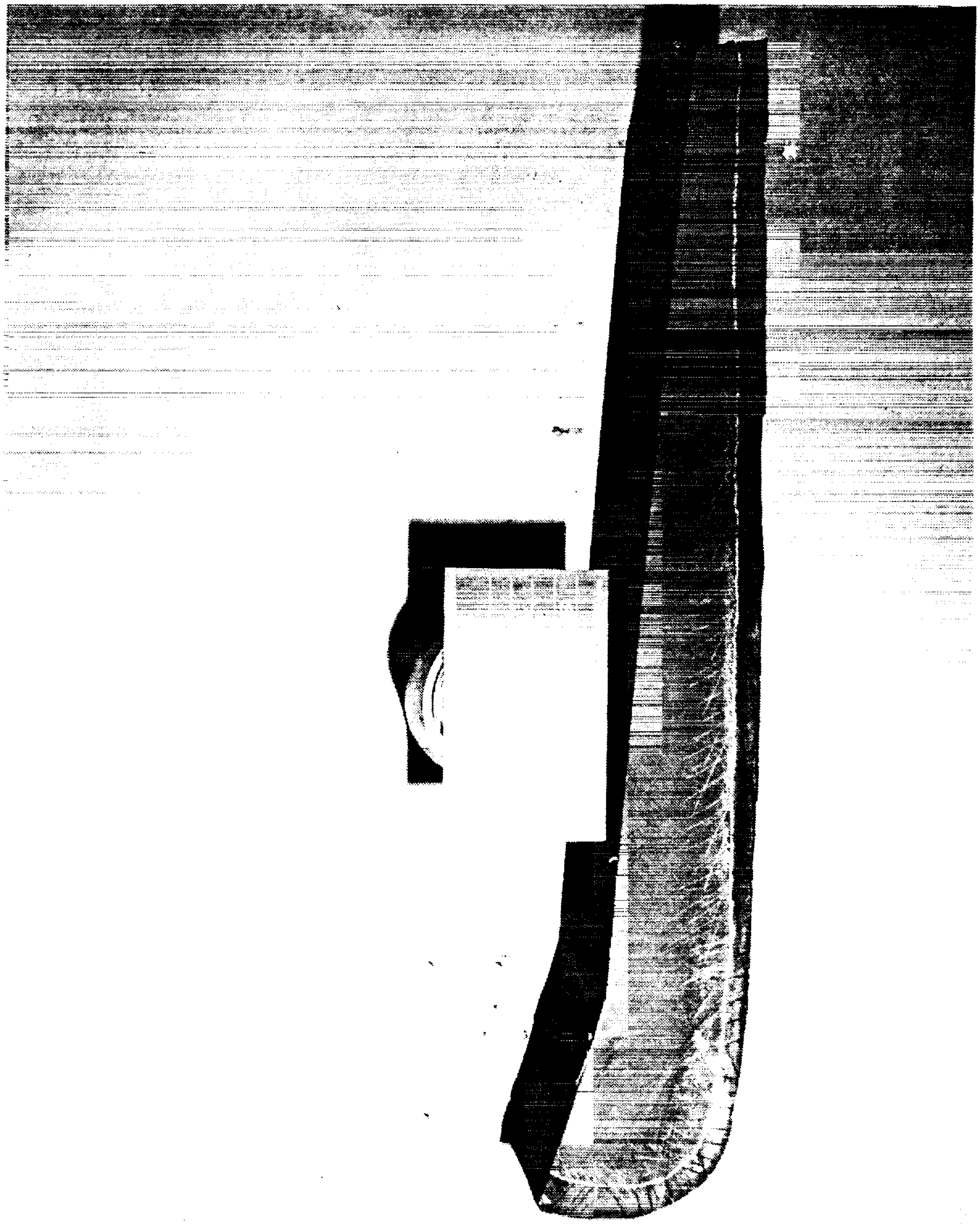

Figure 119 STS-28B Nose Cap Section (270 deg)

Table 12 STS-28B Nose Inlet Rings (-503, -504) Erosion and Char Data

Angular Location	Stations						
	28	30	32	34	36	38	39
0 degrees							
Measured Erosion	1.07	0.87	0.89	0.84	0.81	0.81	0.83
Measured Char	0.63	0.63	0.62	0.51	0.50	0.56	0.65
Adjusted Char*	0.47	0.47	0.47	0.38	0.38	0.42	0.49
2E + 1.25AC	2.73	2.33	2.36	2.16	2.09	2.15	2.27
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.28	0.40	0.25	0.47	0.53	0.41	0.32
90 degrees							
Measured Erosion	1.09	0.90	0.90	0.85	0.87	0.94	0.96
Measured Char	0.72	0.63	0.56	0.51	0.53	0.57	0.64
Adjusted Char*	0.54	0.47	0.42	0.38	0.40	0.43	0.48
2E + 1.25AC	2.86	2.39	2.33	2.18	2.24	2.41	2.52
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.23	0.36	0.27	0.46	0.43	0.25	0.19
180 degrees							
Measured Erosion	1.08	0.94	0.84	0.81	0.84	0.93	0.95
Measured Char	0.71	0.63	0.59	0.56	0.51	0.54	0.66
Adjusted Char*	0.53	0.47	0.44	0.42	0.38	0.41	0.50
2E + 1.25AC	2.83	2.47	2.23	2.15	2.16	2.37	2.52
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.24	0.32	0.32	0.48	0.48	0.28	0.19
270 degrees							
Measured Erosion	1.13	0.91	0.89	0.87	0.85	0.92	0.93
Measured Char	0.65	0.57	0.57	0.51	0.52	0.59	0.67
Adjusted Char*	0.49	0.43	0.43	0.38	0.39	0.44	0.50
2E + 1.25AC	2.87	2.35	2.31	2.22	2.19	2.39	2.49
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	3.000
Margin of Safety	0.22	0.38	0.27	0.43	0.46	0.26	0.21

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

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Table 13 STS-28B Nose Cap Assembly Erosion and Char Data

Angular Location	Stations 1.5	4	6	8	10	12	14	16	18	20	22	24	26
0 degrees													
Measured Erosion	0.27	0.29	0.38	0.40	0.42	0.56	0.49	0.63	0.74	0.95	1.41	1.57	1.14
Measured Char	0.63	0.58	0.56	0.52	0.53	0.47	0.54	0.47	0.41	0.43	0.58	0.71	0.67
Adjusted Char *	0.50	0.46	0.45	0.42	0.42	0.38	0.43	0.38	0.33	0.34	0.46	0.57	0.50
2E + 1.25AC	1.17	1.16	1.32	1.32	1.37	1.59	1.52	1.73	1.89	2.33	3.40	3.85	2.91
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.52	0.76	0.70	0.86	0.95	0.81	1.03	0.91	0.86	0.74	0.39	0.22	0.33
45 degrees													
Measured Erosion	0.28	0.32	0.35	0.39	0.38	0.51	0.50	0.62	0.72	0.95	1.43	1.57	1.10
Measured Char	0.65	0.63	0.58	0.54	0.53	0.49	0.55	0.43	0.45	0.40	0.57	0.70	0.73
Adjusted Char *	0.52	0.50	0.46	0.43	0.42	0.39	0.44	0.34	0.36	0.32	0.46	0.56	0.55
2E + 1.25AC	1.21	1.27	1.28	1.32	1.29	1.51	1.55	1.67	1.89	2.30	3.43	3.84	2.88
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.47	0.60	0.76	0.86	1.07	0.91	0.99	0.97	0.86	0.76	0.37	0.22	0.34
90 degrees													
Measured Erosion	0.31	0.37	0.40	0.52	0.55	0.54	0.58	0.67	0.79	1.04	1.50	1.65	1.15
Measured Char	0.65	0.60	0.62	0.48	0.44	0.51	0.50	0.43	0.45	0.45	0.67	0.71	0.73
Adjusted Char *	0.52	0.48	0.50	0.38	0.35	0.41	0.40	0.34	0.36	0.36	0.54	0.57	0.55
2E + 1.25AC	1.27	1.34	1.42	1.52	1.54	1.59	1.66	1.77	2.03	2.53	3.67	4.01	2.98
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.40	0.52	0.58	0.62	0.73	0.81	0.86	0.86	0.73	0.60	0.28	0.17	0.29
135 degrees													
Measured Erosion	0.28	0.32	0.35	0.45	0.47	0.48	0.64	0.71	0.87	1.10	1.61	1.80	1.31
Measured Char	0.64	0.64	0.61	0.58	0.56	0.61	0.46	0.47	0.43	0.48	0.63	0.66	0.70
Adjusted Char *	0.51	0.51	0.49	0.46	0.45	0.49	0.37	0.38	0.34	0.38	0.50	0.53	0.53
2E + 1.25AC	1.20	1.28	1.31	1.48	1.50	1.57	1.74	1.89	2.17	2.68	3.85	4.26	3.28
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.48	0.59	0.72	0.66	0.78	0.83	0.77	0.74	0.62	0.51	0.22	0.10	0.18

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

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Table 13 STS-28B Nose Cap Assembly Erosion and Char Data (Cont)

Angular Location	Stations												
	1.5	4	6	8	10	12	14	16	18	20	22	24	26
180 degrees													
Measured Erosion	0.24	0.24	0.39	0.45	0.42	0.53	0.61	0.70	0.81	1.10	1.63	1.83	1.33
Measured Char	0.70	0.71	0.62	0.53	0.57	0.53	0.49	0.51	0.45	0.43	0.65	0.66	0.60
Adjusted Char *	0.56	0.57	0.50	0.42	0.46	0.42	0.39	0.41	0.36	0.34	0.52	0.53	0.45
2E + 1.25AC	1.18	1.19	1.40	1.43	1.41	1.59	1.71	1.91	2.07	2.63	3.91	4.32	3.22
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.51	0.71	0.61	0.72	0.89	0.81	0.81	0.73	0.69	0.54	0.21	0.09	0.20
225 degrees													
Measured Erosion	0.30	0.30	0.35	0.43	0.45	0.52	0.57	0.69	0.78	1.03	1.53	1.69	1.18
Measured Char	0.65	0.65	0.65	0.62	0.55	0.53	0.55	0.54	0.47	0.43	0.59	0.66	0.74
Adjusted Char *	0.52	0.52	0.52	0.50	0.44	0.42	0.44	0.43	0.38	0.34	0.47	0.53	0.56
2E + 1.25AC	1.25	1.25	1.35	1.48	1.45	1.57	1.69	1.92	2.03	2.49	3.65	4.04	3.05
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.42	0.63	0.67	0.66	0.84	0.83	0.83	0.72	0.73	0.63	0.29	0.16	0.27
270 degrees													
Measured Erosion	0.26	0.32	0.35	0.49	0.47	0.53	0.61	0.74	0.85	1.13	1.73	1.97	1.43
Measured Char	0.59	0.63	0.57	0.50	0.51	0.51	0.52	0.40	0.44	0.40	0.55	0.58	0.71
Adjusted Char *	0.47	0.50	0.46	0.40	0.41	0.41	0.42	0.32	0.35	0.32	0.44	0.46	0.53
2E + 1.25AC	1.11	1.27	1.27	1.48	1.45	1.57	1.74	1.88	2.14	2.66	4.01	4.52	3.53
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.60	0.60	0.77	0.66	0.84	0.83	0.77	0.75	0.64	0.52	0.18	0.04	0.10
315 degrees													
Measured Erosion	NA	0.28	0.35	0.37	0.35	0.45	0.52	0.62	0.75	0.95	1.45	1.59	1.15
Measured Char	NA	0.63	0.56	0.53	0.50	0.44	0.45	0.43	0.40	0.41	0.54	0.63	0.60
Adjusted Char *	NA	0.50	0.45	0.42	0.40	0.35	0.36	0.34	0.32	0.33	0.43	0.50	0.45
2E + 1.25AC	NA	1.19	1.26	1.27	1.20	1.34	1.49	1.67	1.90	2.31	3.44	3.81	2.86
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.71	0.78	0.94	1.22	1.15	1.07	0.97	0.85	0.76	0.37	0.23	0.35

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

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Figure 120 STS-28B Cowl Ring Section (0 deg)

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Figure 121 STS-28B Cowl Ring Section (90 deg)

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Figure 122 STS-28B Cowl Ring Section (180 deg)

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Figure 123 STS-28B Cowl Ring Section (270 deg)

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Table 14 STS-28B Cowl/OBR Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10	11.3
0 degrees												
Measured Erosion	0.23	0.26	0.29	0.30	0.27	NA	NA	NA	NA	NA	0.04	0.04
Measured Char	0.56	0.58	0.56	0.55	0.57	NA	NA	NA	NA	NA	0.79	0.75
Adjusted Char *	0.45	0.46	0.45	0.44	0.46	NA	NA	NA	NA	NA	0.63	0.60
2E + 1.25AC	1.02	1.10	1.14	1.15	1.11	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.01	0.96
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.38	0.36	0.38	0.44	0.56	NA	NA	NA	NA	NA	0.67	0.77
45 degrees												
Measured Erosion	NA	0.29	0.31	0.25	0.25	NA	NA	NA	NA	NA	0.00	0.00
Measured Char	NA	0.55	0.59	0.65	0.64	NA	NA	NA	NA	NA	0.82	0.83
Adjusted Char *	NA	0.44	0.47	0.52	0.51	NA	NA	NA	NA	NA	0.66	0.66
2E + 1.25AC	NA	1.13	1.21	1.15	1.14	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	0.98	1.00
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.33	0.30	0.44	0.52	NA	NA	NA	NA	NA	0.71	0.71
90 degrees												
Measured Erosion	0.28	0.31	0.32	0.32	0.31	NA	NA	NA	NA	NA	0.02	0.00
Measured Char	0.54	0.56	0.57	0.63	0.67	NA	NA	NA	NA	NA	0.93	1.00
Adjusted Char *	0.43	0.45	0.46	0.50	0.54	NA	NA	NA	NA	NA	0.74	0.80
2E + 1.25AC	1.10	1.18	1.21	1.27	1.29	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.15	1.20
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.28	0.27	0.30	0.30	0.34	NA	NA	NA	NA	NA	0.47	0.42
135 degrees												
Measured Erosion	NA	0.24	0.27	0.26	0.25	0.24	0.21	0.18	NA	NA	0.01	0.06
Measured Char	NA	0.60	0.64	0.68	0.66	0.68	0.70	0.79	NA	NA	1.01	0.94
Adjusted Char *	NA	0.48	0.51	0.54	0.53	0.54	0.56	0.63	NA	NA	0.81	0.75
2E + 1.25AC	NA	1.08	1.18	1.20	1.16	1.16	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.16	1.22	NA	NA	1.23	1.22
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.39	0.34	0.38	0.49	0.56	0.64	0.61	NA	NA	0.37	0.40

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1 \quad \text{(Stations 0 through 5)}$$

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{1.5 \times (\text{erosion} + \text{adj char*})} - 1 \quad \text{(Stations 6 through 11.3)}$$

Table 14 STS-28B Cowl/OBR Erosion and Char Data (Cont)

Angular Location	Stations											
180 degrees	0	1	2	3	4	5	6	7	8	9	10	11.3
Measured Erosion	0.23	0.27	0.31	0.28	0.21	0.20	0.17	0.16	NA	0.02	0.03	0.04
Measured Char	0.63	0.60	0.65	0.72	0.72	0.77	0.78	0.78	NA	0.92	0.86	0.90
Adjusted Char *	0.50	0.48	0.52	0.58	0.58	0.62	0.62	0.62	NA	0.74	0.69	0.72
2E + 1.25AC	1.09	1.14	1.27	1.28	1.14	1.17	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.19	1.18	NA	1.13	1.08	1.14
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.29	0.31	0.24	0.29	0.52	0.55	0.59	0.66	NA	0.48	0.57	0.49
225 degrees												
Measured Erosion	0.21	0.25	0.28	0.25	0.21	NA	NA	NA	NA	NA	0.04	0.06
Measured Char	0.64	0.65	0.61	0.72	0.76	NA	NA	NA	NA	NA	0.89	0.88
Adjusted Char *	0.51	0.52	0.49	0.58	0.61	NA	NA	NA	NA	NA	0.71	0.70
2E + 1.25AC	1.06	1.15	1.17	1.22	1.18	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.13	1.15
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.33	0.30	0.35	0.36	0.47	NA	NA	NA	NA	NA	0.50	0.49
270 degrees												
Measured Erosion	0.32	0.31	0.37	0.34	0.31	0.25	0.25	0.26	NA	0.05	0.06	0.05
Measured Char	0.42	0.52	0.55	0.63	0.63	0.67	0.67	0.70	NA	0.91	0.87	0.93
Adjusted Char *	0.34	0.42	0.44	0.50	0.50	0.54	0.54	0.56	NA	0.73	0.70	0.74
2E + 1.25AC	1.06	1.14	1.29	1.31	1.25	1.17	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	1.18	1.23	NA	1.17	1.13	1.19
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	0.33	0.31	0.22	0.26	0.39	0.55	0.60	0.59	NA	0.43	0.49	0.43
315 degrees												
Measured Erosion	NA	0.23	0.28	0.28	0.27	NA	NA	NA	NA	NA	0.10	0.03
Measured Char	NA	0.58	0.59	0.65	0.70	NA	NA	NA	NA	NA	0.76	0.88
Adjusted Char *	NA	0.46	0.47	0.52	0.56	NA	NA	NA	NA	NA	0.61	0.70
2E + 1.25AC	NA	1.04	1.15	1.21	1.24	NA	----	----	----	----	----	----
1.5(E + AC)	----	----	----	----	----	----	NA	NA	NA	NA	1.06	1.10
RSRM Min Liner Thickness	1.410	1.499	1.577	1.655	1.733	1.811	1.889	1.957	1.600	1.674	1.687	1.703
Margin of Safety	NA	0.44	0.37	0.37	0.40	NA	NA	NA	NA	NA	0.59	0.55

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1 \qquad \text{(Stations 0 through 5)}$$

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{1.5 \times (\text{erosion} + \text{adj char*})} - 1 \qquad \text{(Stations 6 through 11.3)}$$

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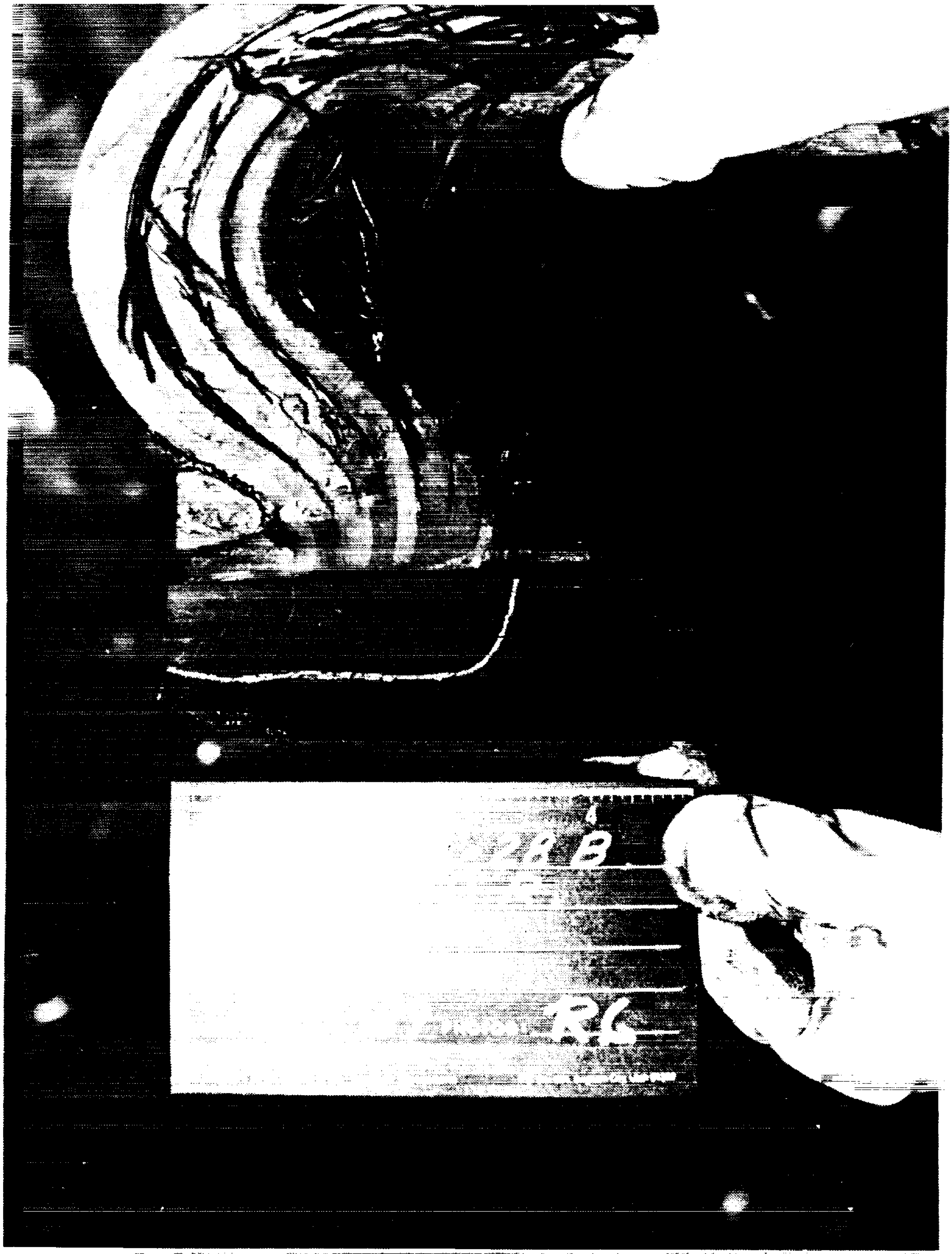

Figure 124 STS-28B Outer Boot Ring Section (0 deg)

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Figure 125 STS-28B Outer Boot Ring Section (90 deg)

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Figure 126 STS-28B Outer Boot Ring Section (180 deg)

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Figure 127 STS-28B Outer Boot Ring Section (270 deg)

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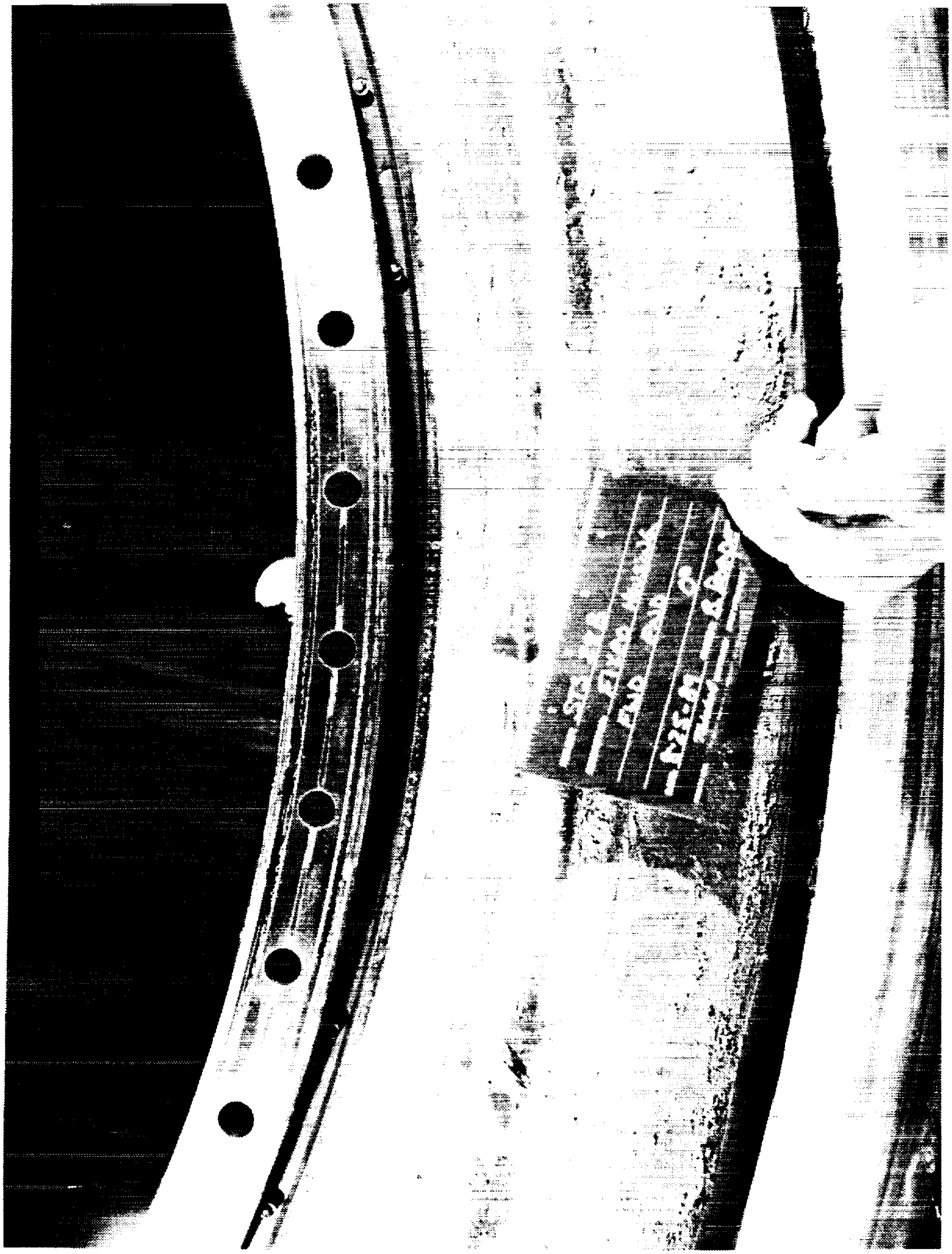

Figure 128 STS-28B Flex Boot (Cavity Side - 0 deg)

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Figure 129 STS-28B Flex Boot (Cavity Side - 120 deg)

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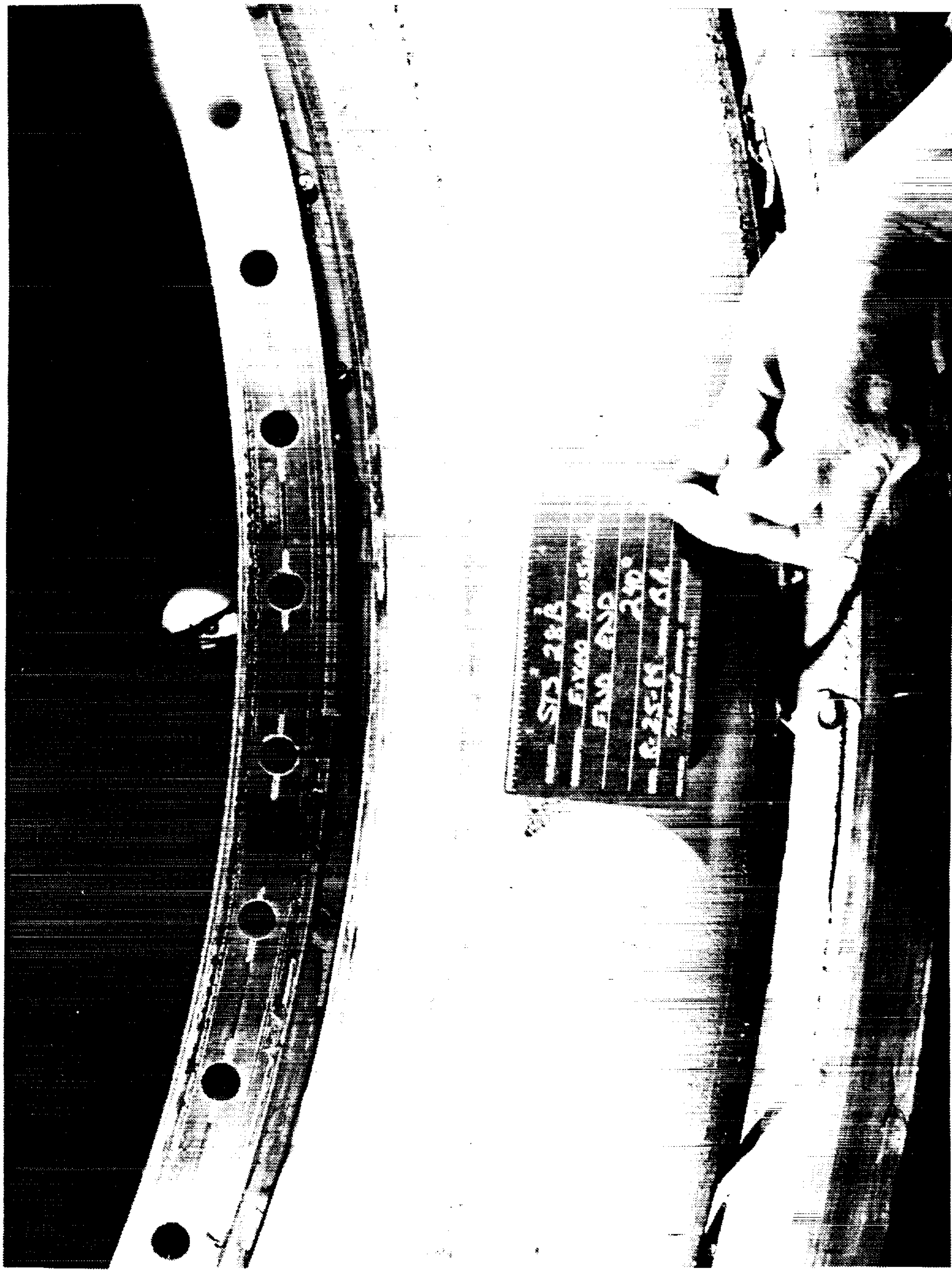
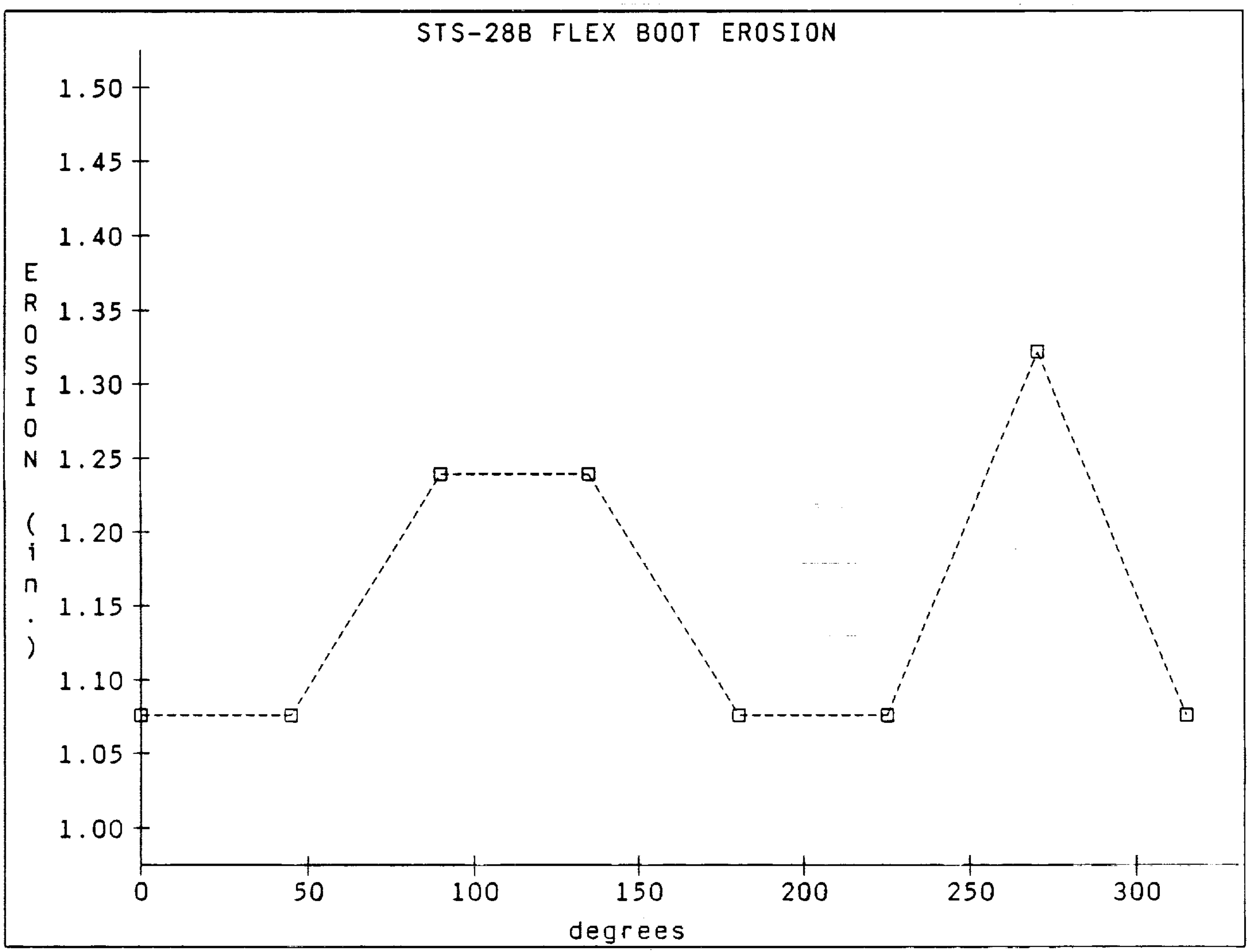


Figure 130 STS-28B Flex Boot (Cavity Side - 240 deg)

Table 15 STS-28B Flex Boot Data Performance Margins of Safety

Degree Location	Remaining Plies	Max Material Affected Depth (in.)	Margin of Safety*
0	4	1.08	0.54
45	4	1.08	0.54
90	3 1/2	1.24	0.34
135	3 1/2	1.24	0.34
180	4	1.08	0.54
225	4	1.08	0.54
270	3 1/4	1.32	0.26
315	4	1.08	0.54

$$* \text{ PMS} = \frac{\text{minimum overall thickness}}{(1.5 \times \text{max material affected depth})} - 1$$



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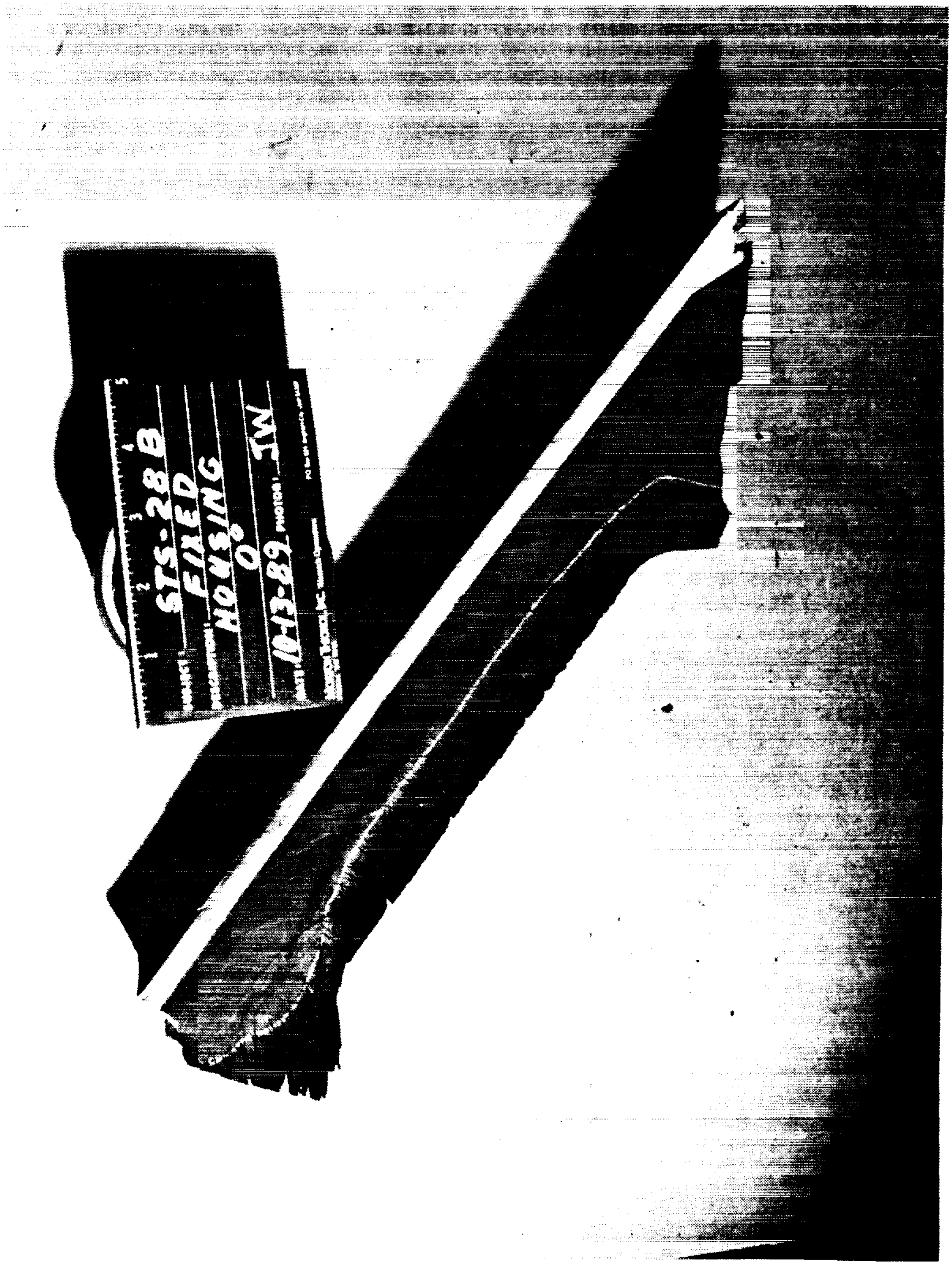

Figure 131 STS-28B Fixed Housing Section (0 deg)

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Figure 132 STS-28B Fixed Housing Section (90 deg)

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Figure 133 STS-28B Fixed Housing Section (180 deg)

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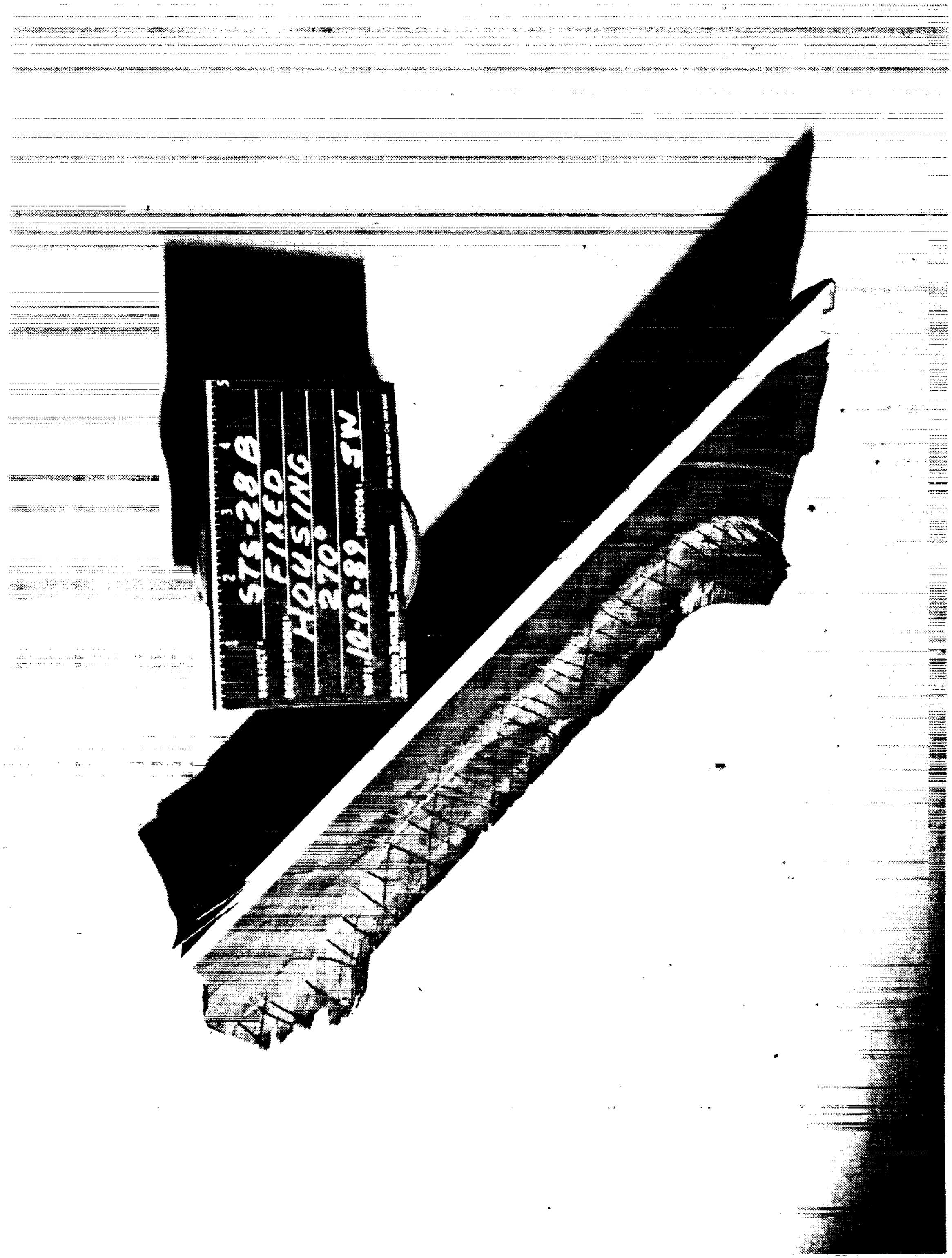

Figure 134 STS-28B Fixed Housing Section (270 deg)

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Table 16 STS-28B Fixed Housing Insulation Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10.75
0 degrees											
Measured Erosion	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.36
Measured Char	1.00	0.87	0.91	0.94	0.92	0.90	0.94	0.96	0.74	0.51	1.27
Adjusted Char*	0.80	0.70	0.73	0.75	0.74	0.72	0.75	0.77	0.59	0.41	1.02
2E + 1.25AC	1.20	0.93	0.91	0.94	0.92	0.90	0.94	0.96	0.74	0.63	1.99
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.17	1.24	1.01	0.94	0.99	1.03	0.95	0.91	1.48	2.85	0.53
90 degrees											
Measured Erosion	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.56
Measured Char	1.20	1.07	0.97	0.93	1.01	1.04	1.00	1.04	0.92	0.89	1.28
Adjusted Char*	0.96	0.86	0.78	0.74	0.81	0.83	0.80	0.83	0.74	0.71	1.02
2E + 1.25AC	1.28	1.07	0.97	0.93	1.01	1.04	1.00	1.04	0.92	1.01	2.40
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.97	0.94	0.88	0.96	0.81	0.76	0.83	0.76	1.00	1.40	0.27
180 degrees											
Measured Erosion	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Measured Char	1.02	1.16	1.13	1.12	1.16	1.15	1.12	1.14	1.03	1.10	2.01
Adjusted Char*	0.82	0.93	0.90	0.90	0.93	0.92	0.90	0.91	0.82	0.88	1.61
2E + 1.25AC	1.24	1.16	1.13	1.12	1.16	1.15	1.12	1.14	1.03	1.10	2.15
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.07	0.79	0.62	0.63	0.58	0.59	0.64	0.61	0.78	1.21	0.42
270 degrees											
Measured Erosion	0.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	NA
Measured Char	1.12	1.12	1.02	1.02	0.98	1.01	1.04	1.04	0.80	0.89	NA
Adjusted Char*	0.90	0.90	0.82	0.82	0.78	0.81	0.83	0.83	0.64	0.71	NA
2E + 1.25AC	1.32	1.28	1.02	1.02	0.98	1.01	1.04	1.04	0.80	0.97	NA
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.88	0.63	0.79	0.79	0.87	0.81	0.76	0.76	1.30	1.50	NA

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{Erosion} + 1.25 \times \text{Adj Char*}} - 1$$

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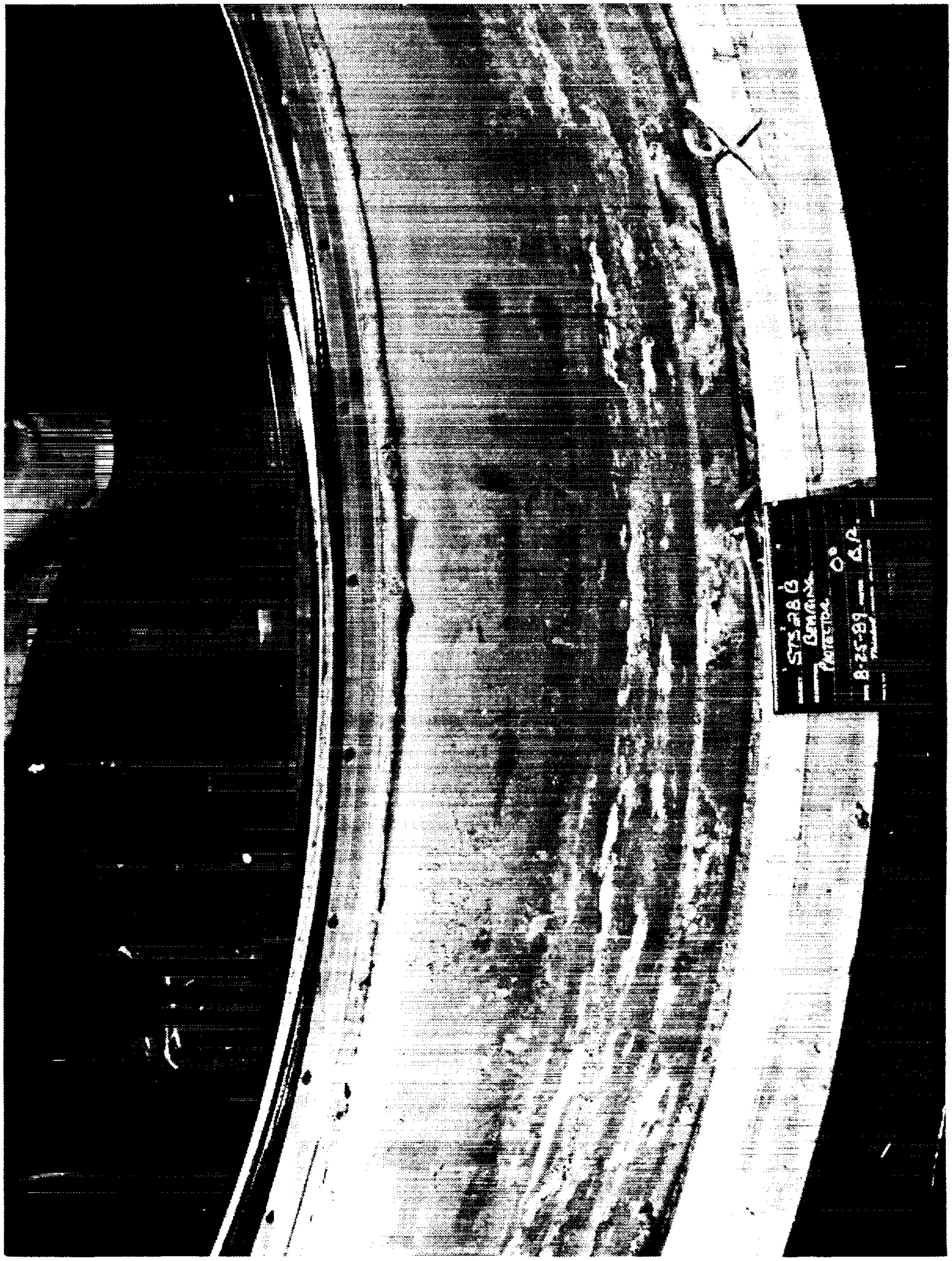

Figure 135 STS-28B Bearing Protector (0 deg)

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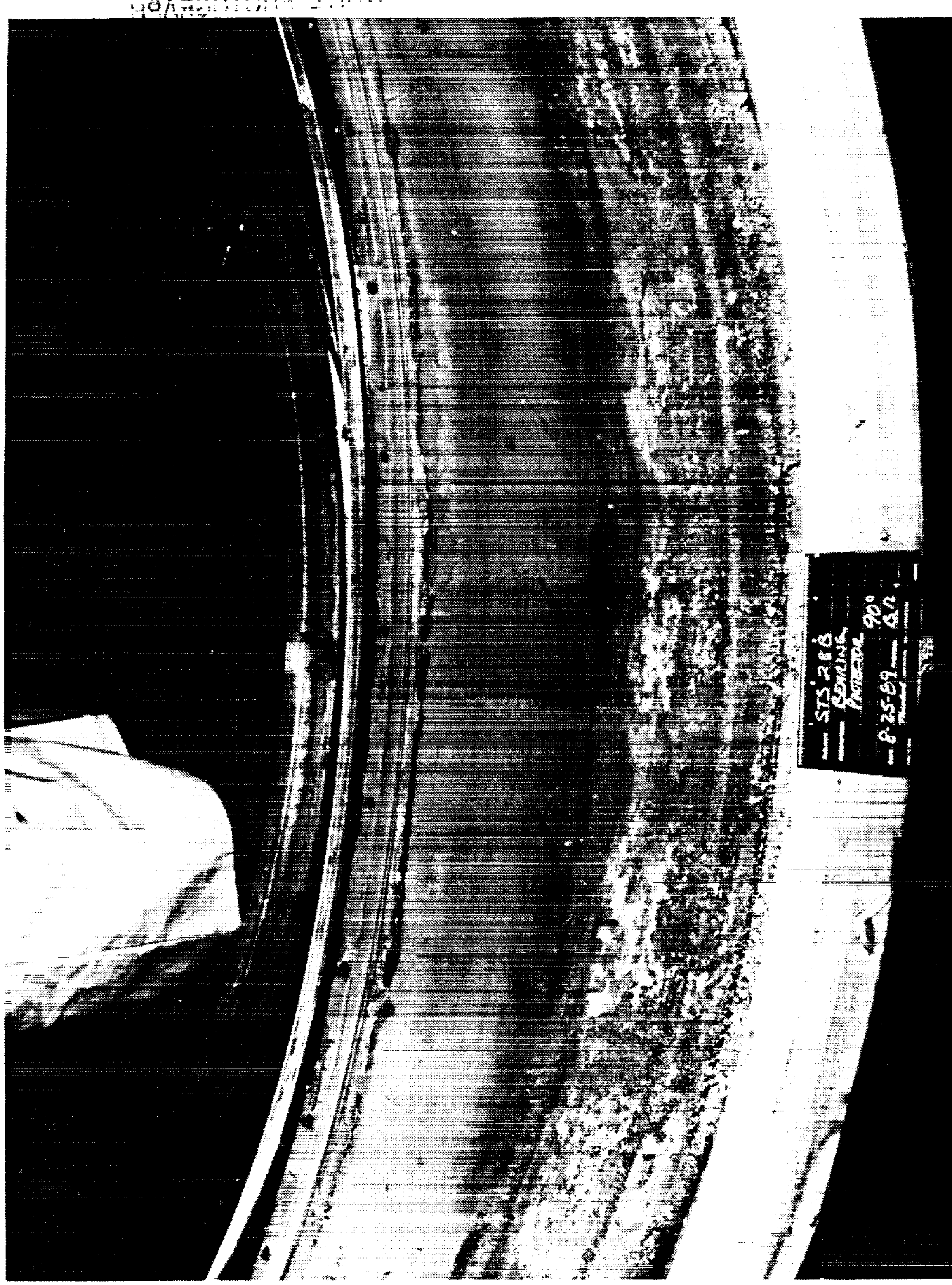

Figure 136 STS-28B Bearing Protector (90 deg)

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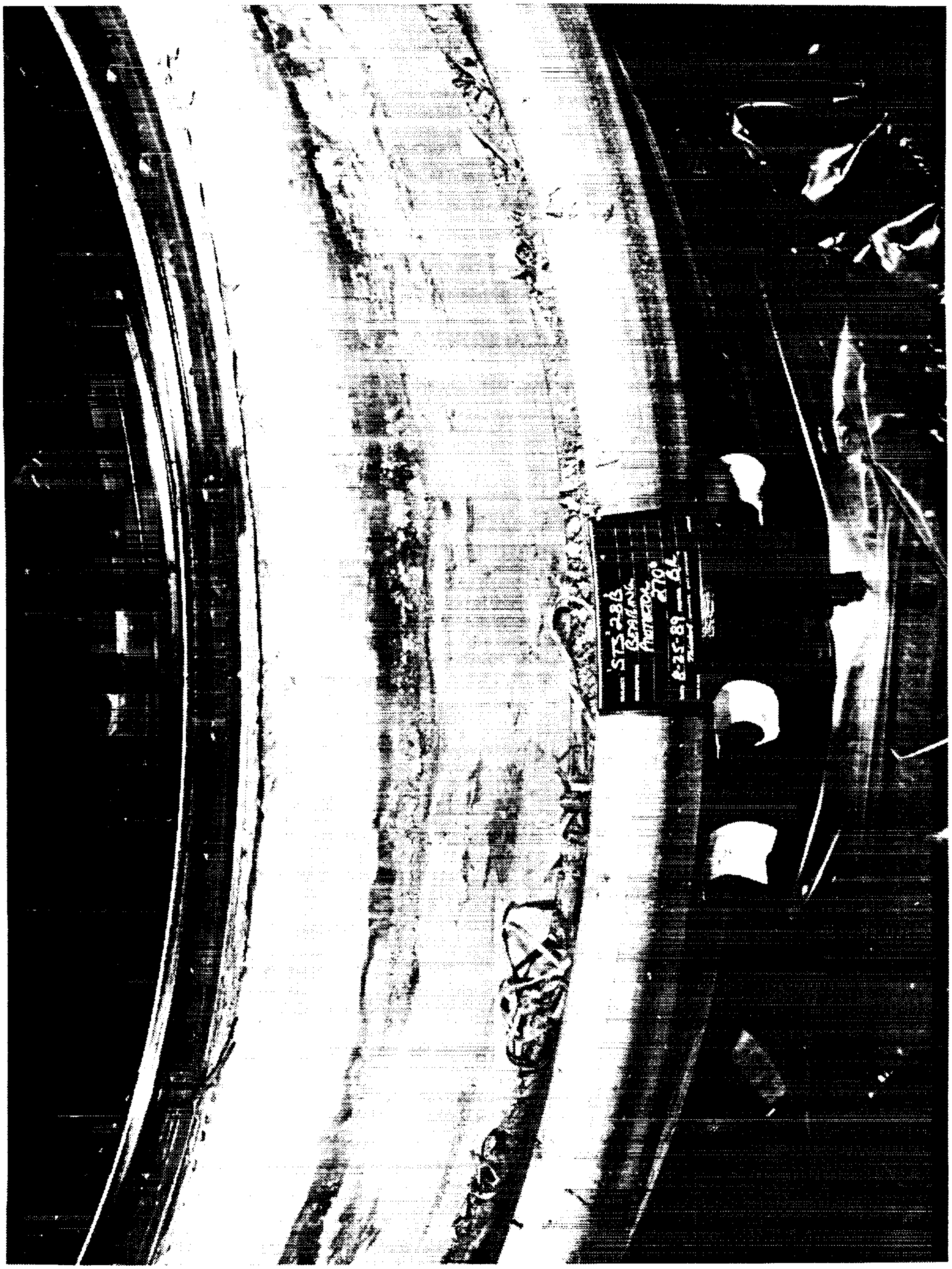

Figure 137 STS-28B Bearing Protector (270 deg)

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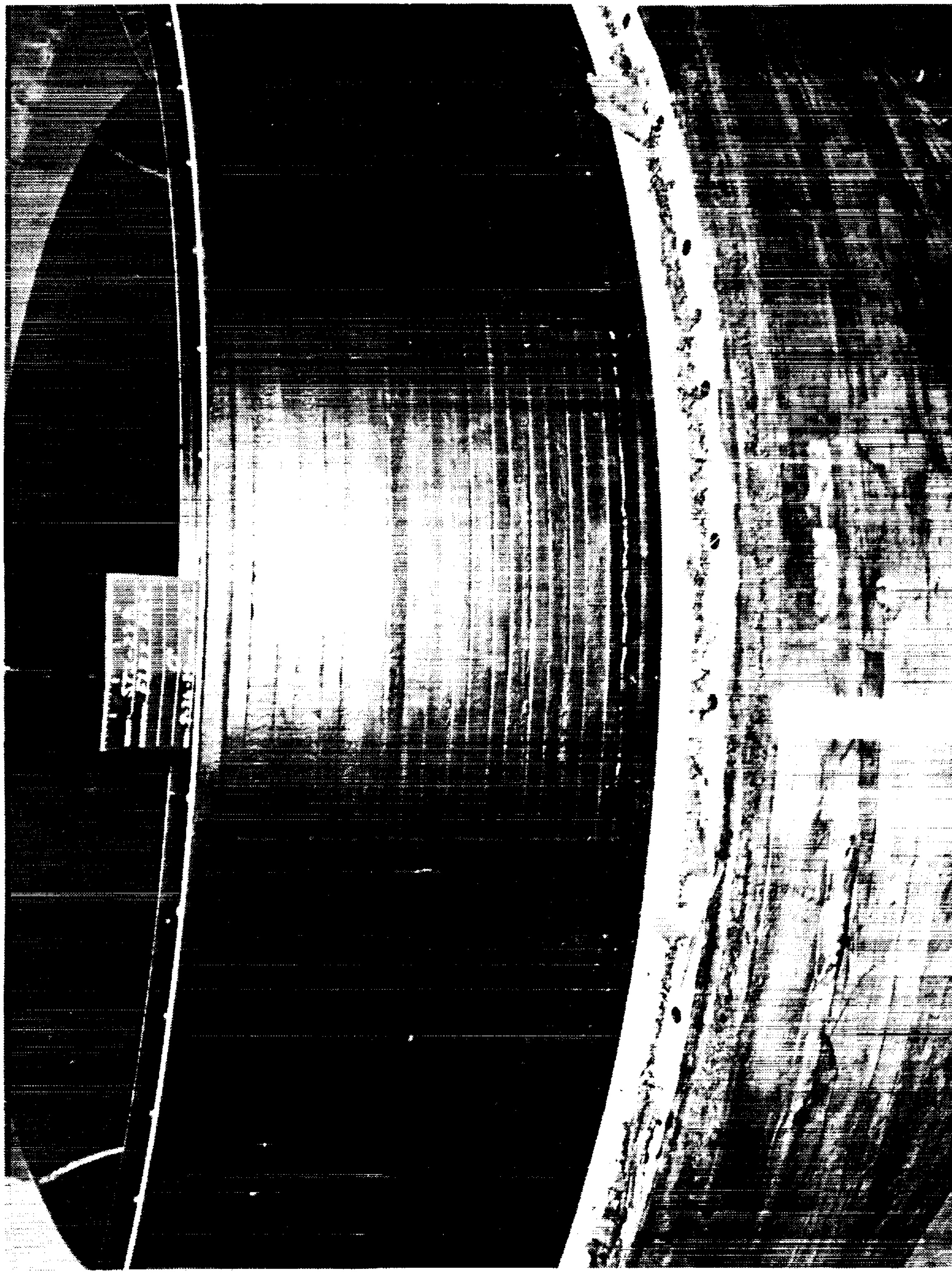

Figure 138 STS-28B Flex Bearing (0 deg)

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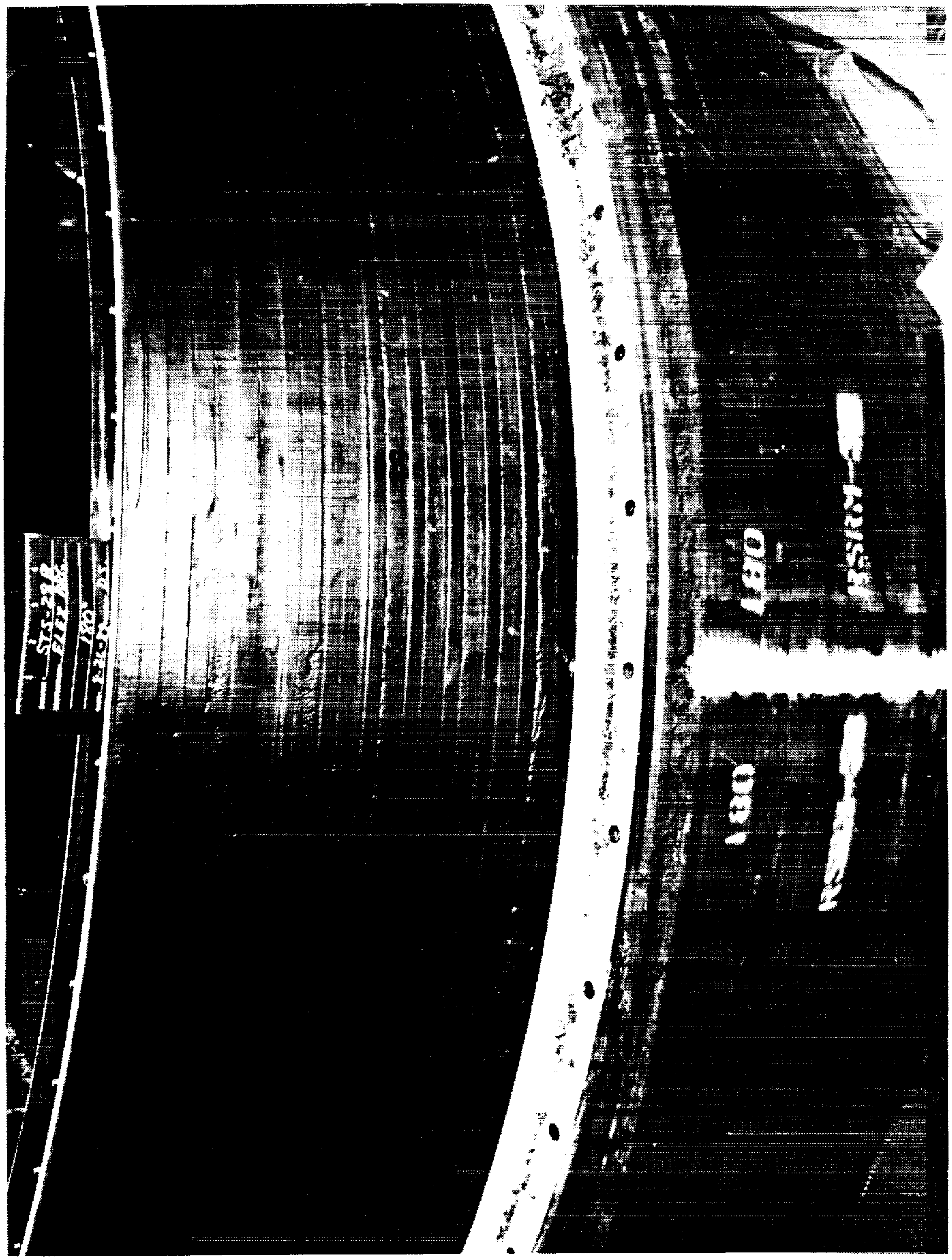

Figure 139 STS-28B Flex Bearing (180 deg)

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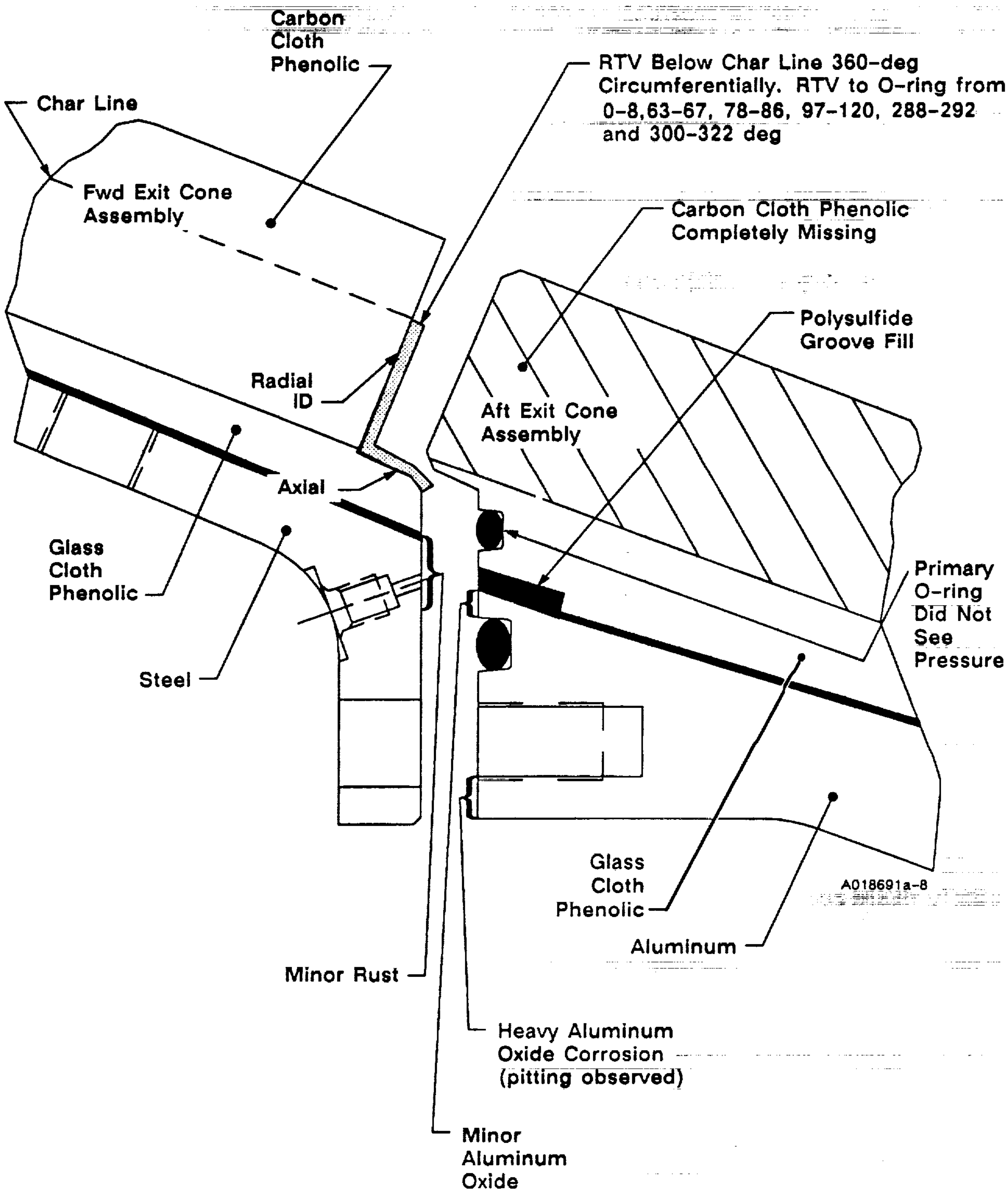

Figure 140 STS-28B Aft Exit Cone-to-Forward Exit Cone Joint Interface (Joint #1)

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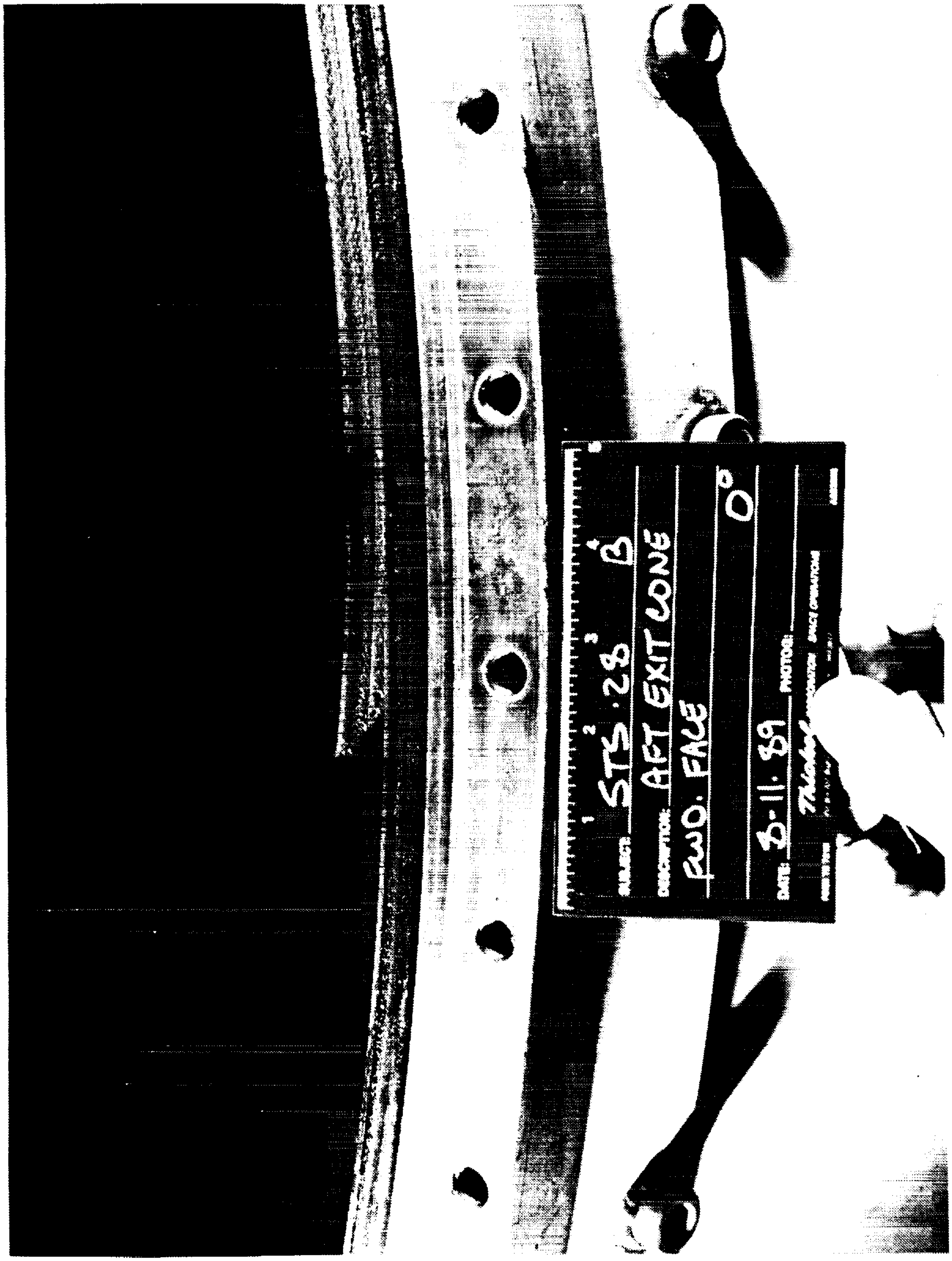

Figure 141 STS-28B Aft Exit Cone Forward End (0 deg)

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Figure 142 STS-28B Aft Exit Cone Forward End (120 deg)

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Figure 143 STS-28B Aft Exit Cone Forward End (240 deg)

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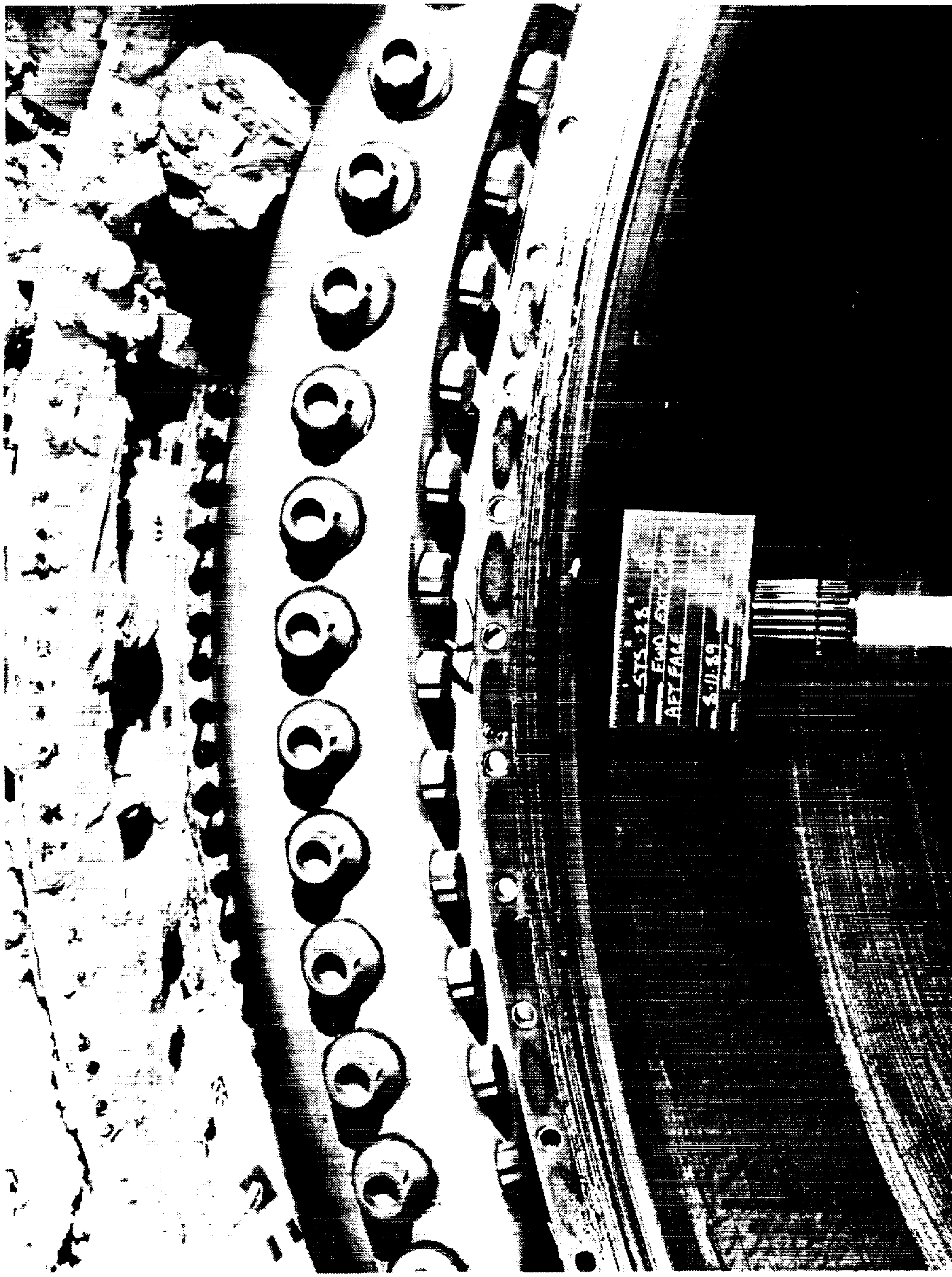

Figure 144 STS-28B Forward Exit Cone - Aft End (0 deg)

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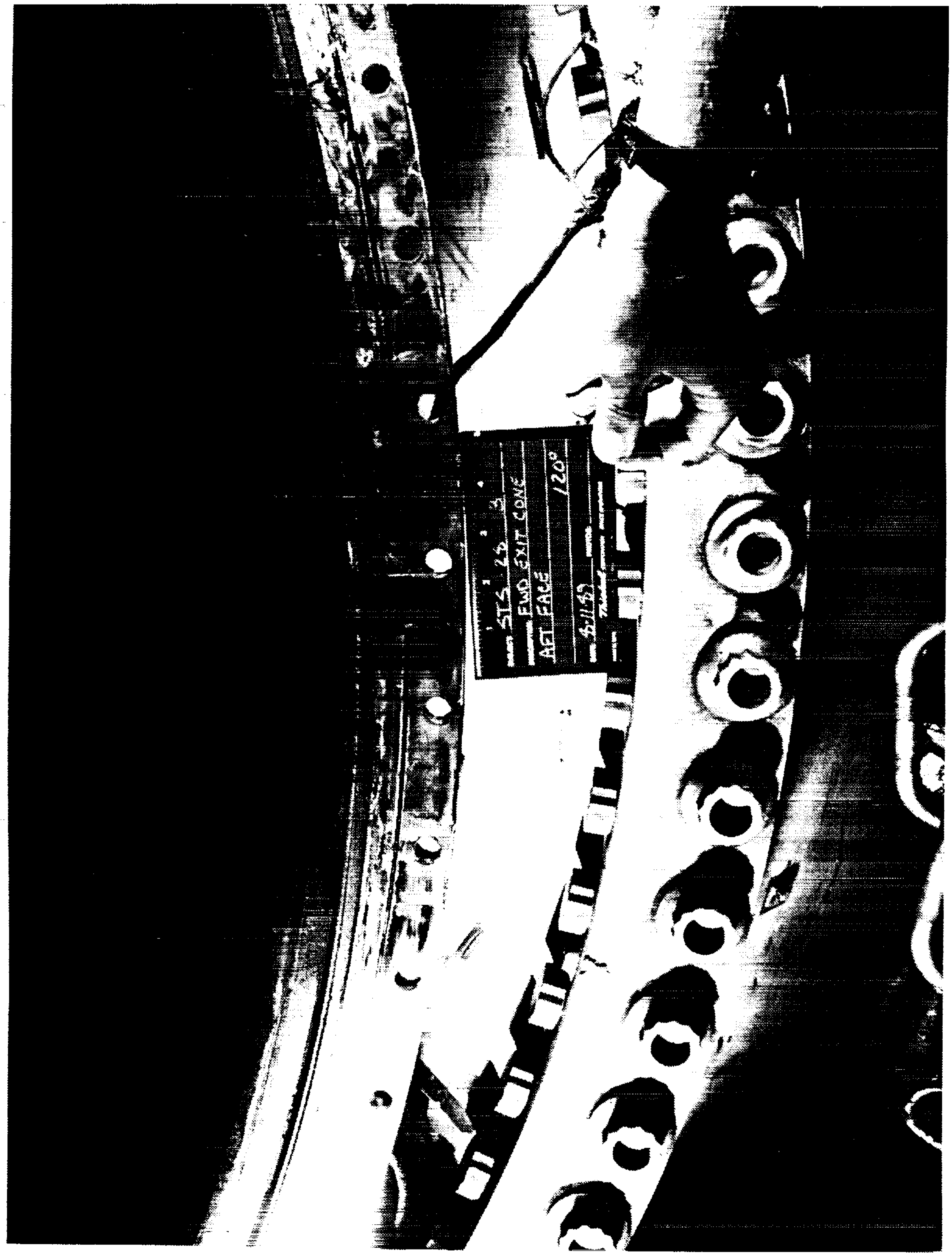

Figure 145 STS-28B Forward Exit Cone - Aft End (120 deg)

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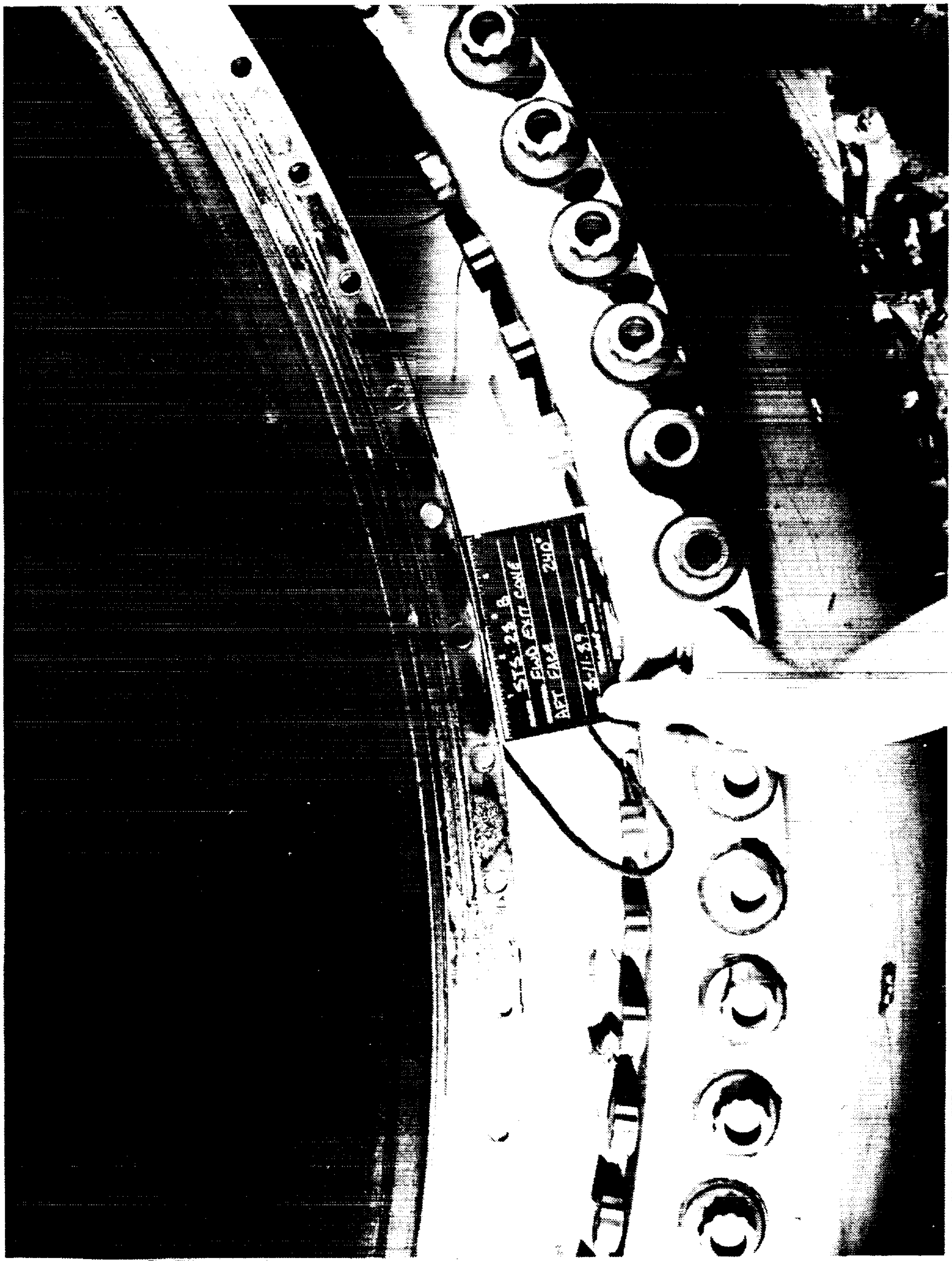

Figure 146 STS-28B Forward Exit Cone - Aft End (240 deg)

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Figure 147 STS-28B Forward Exit Cone - Aft End (91.8 deg)

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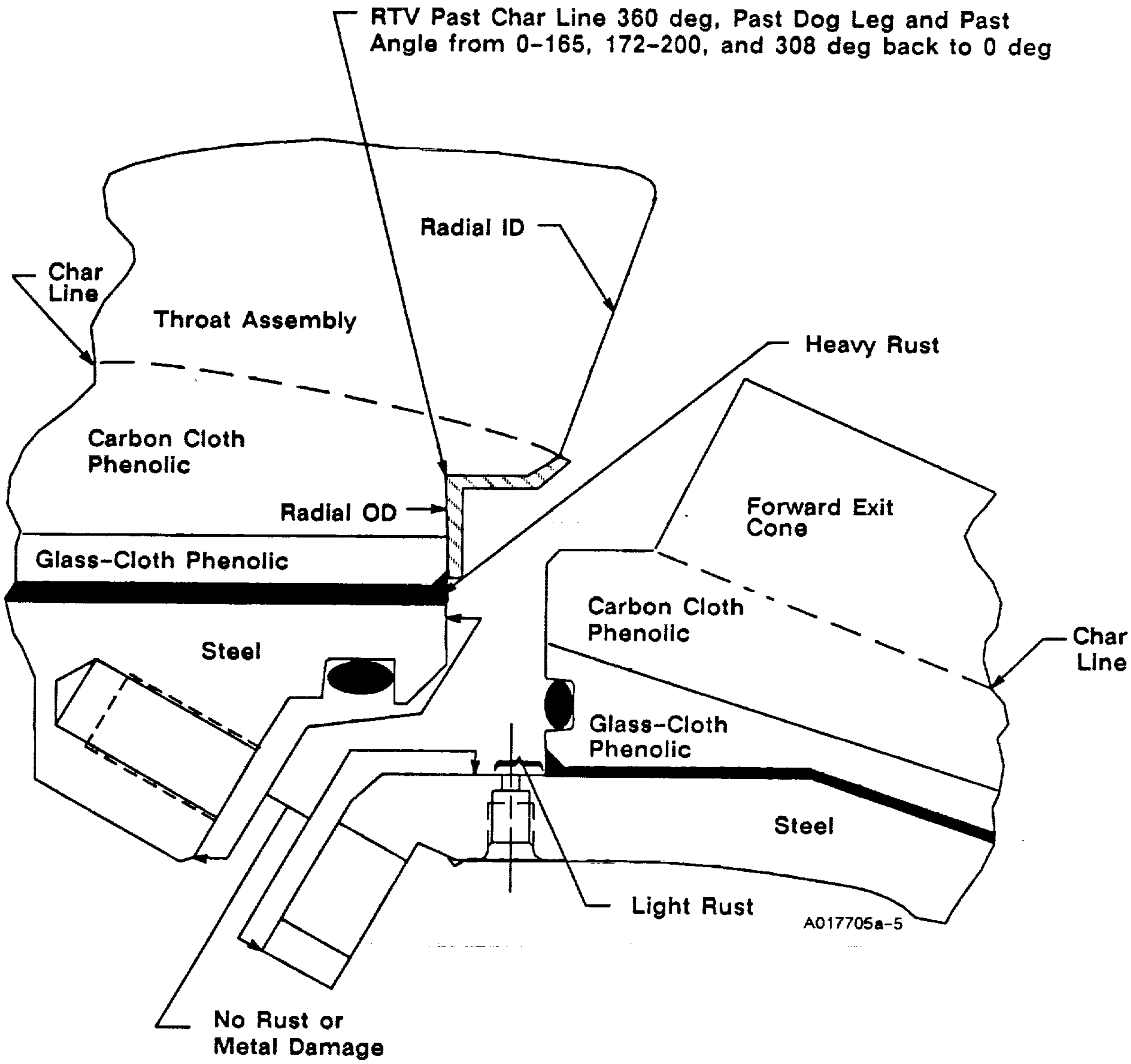

Figure 148 STS-28B Throat/Forward Exit Cone Joint (Joint #4)

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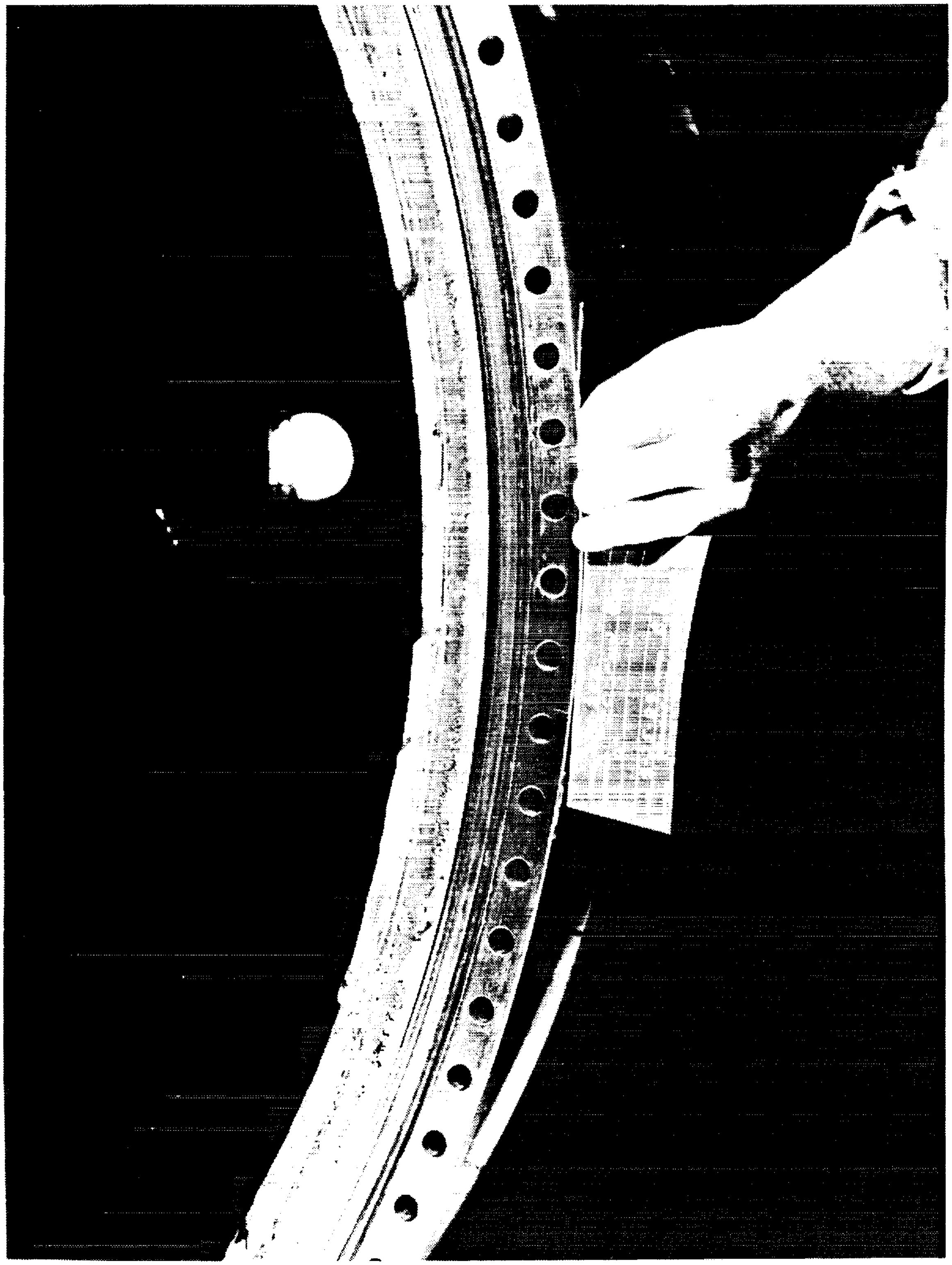

Figure 149 STS-28B Forward Exit Cone - Forward End (0 deg)

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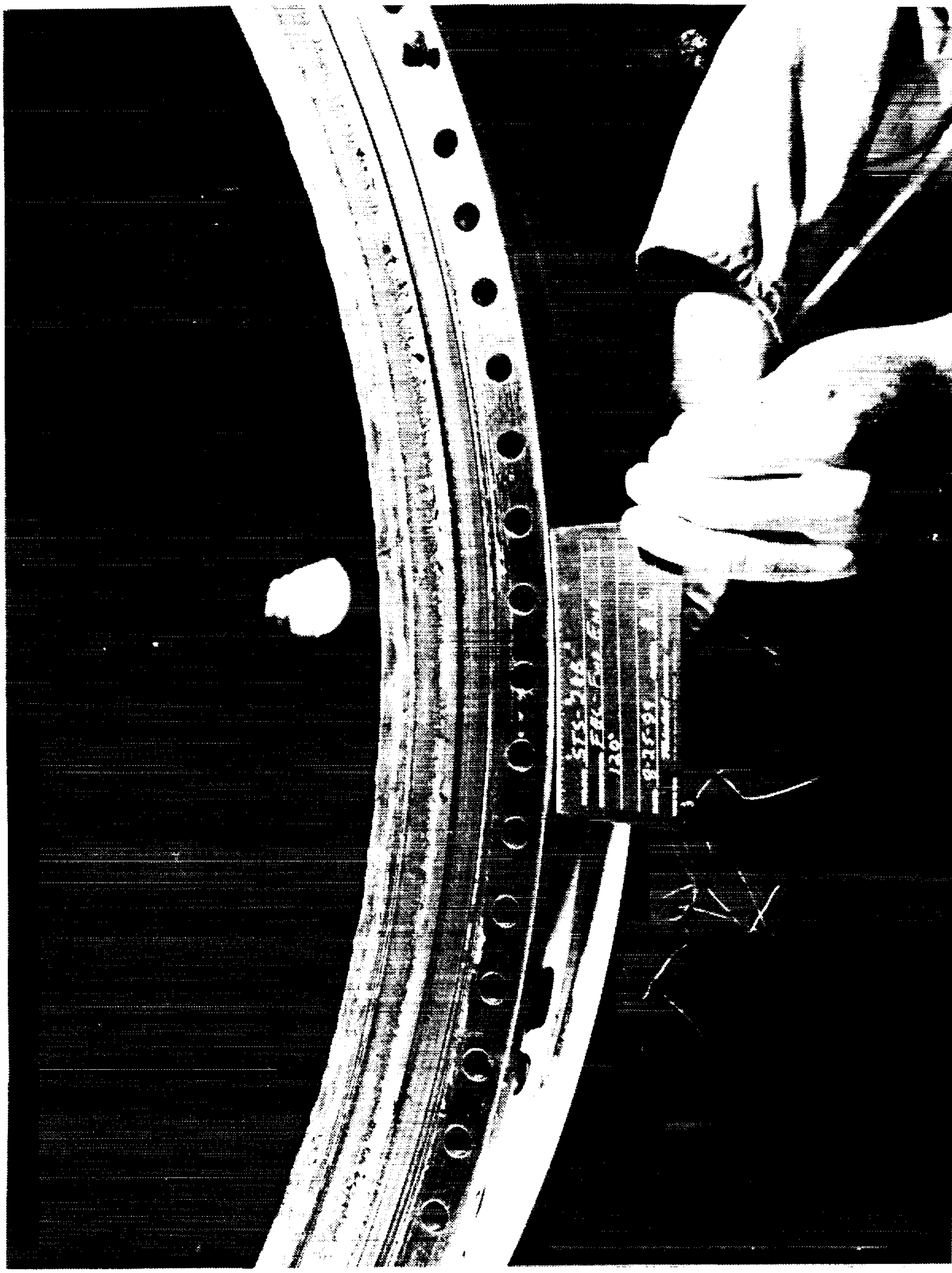

Figure 150 STS-28B Forward Exit Cone - Forward End (120 deg)

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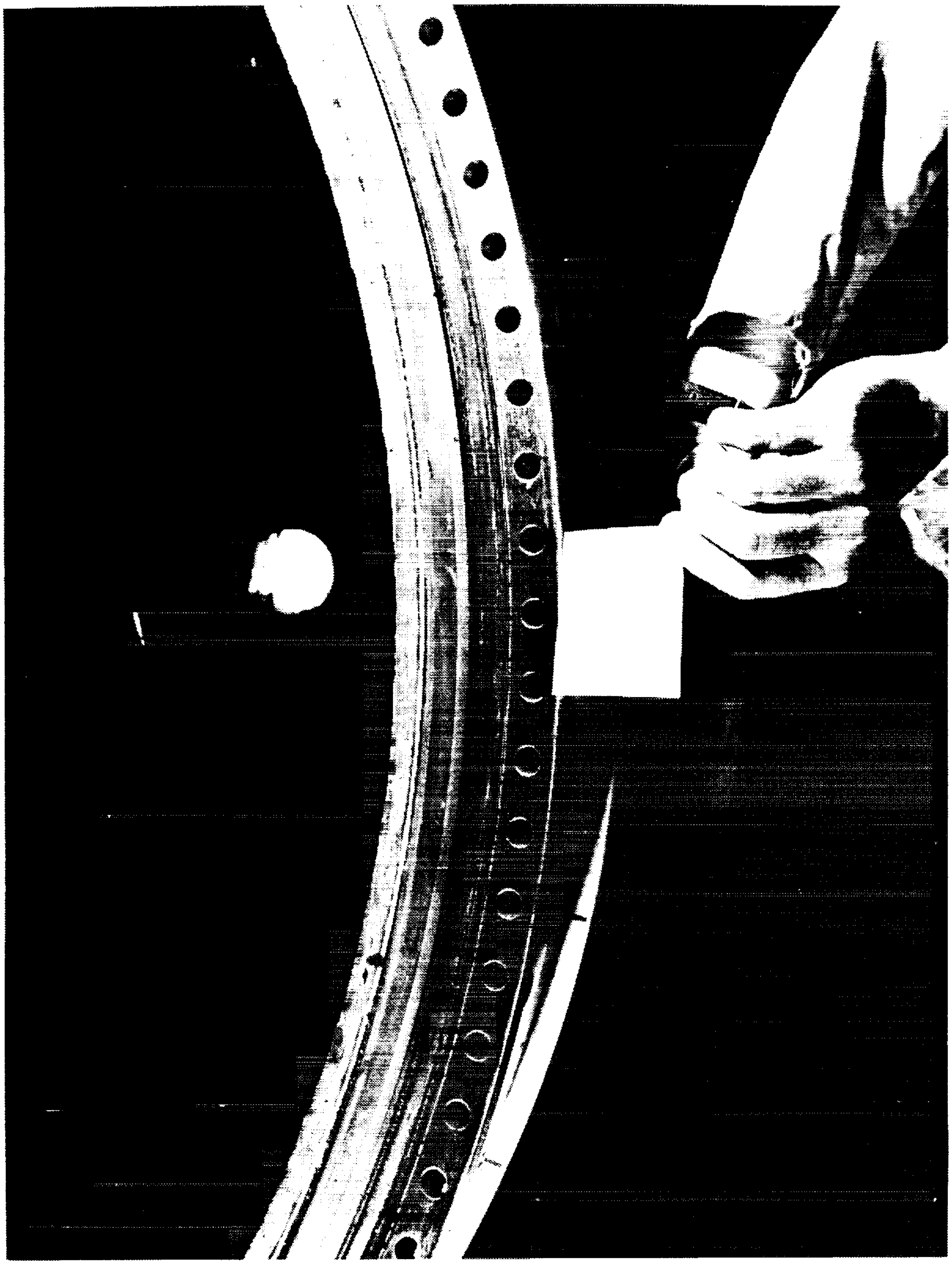

Figure 151 STS-28B Forward Exit Cone - Forward End (240 deg)

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Figure 152 STS-28B Throat Aft End (0 deg)

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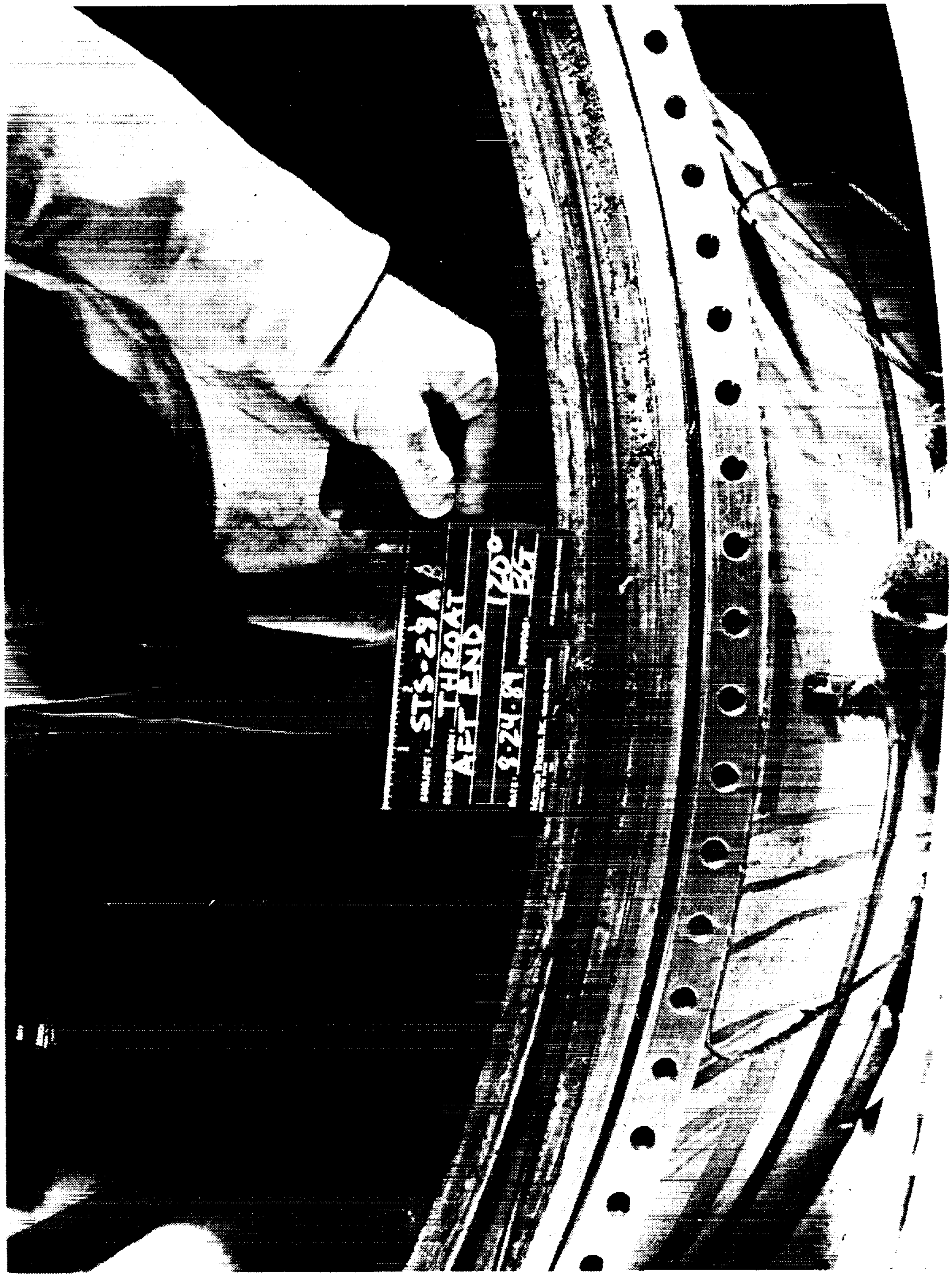

Figure 153 STS-28B Throat Aft End (120 deg)

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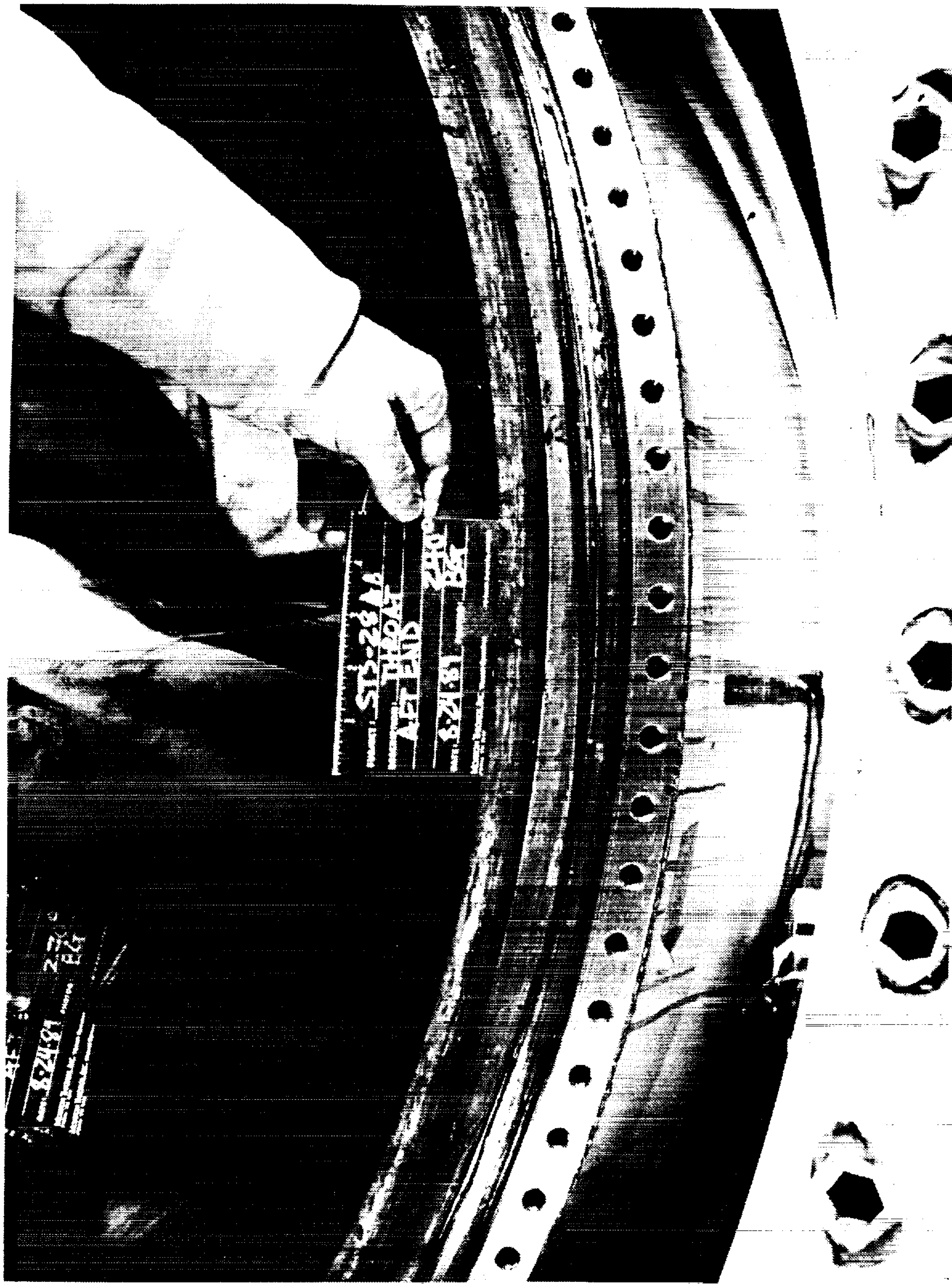

Figure 154 STS-28B Throat Aft End (240 deg)

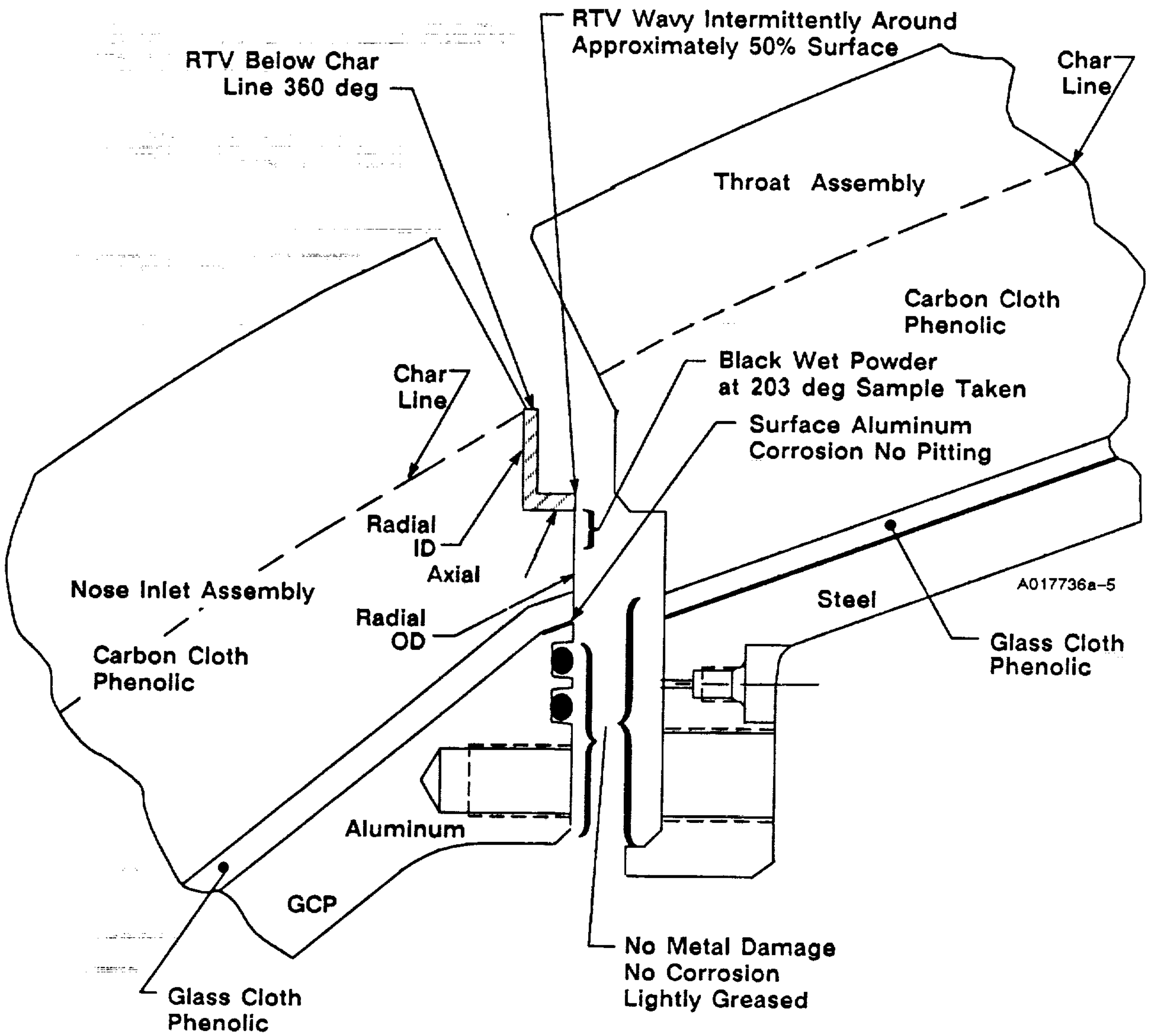

Figure 155 STS-28B Nose Inlet/Throat Housing Joint (Joint #3)

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Figure 156 STS-28B Throat - Forward End (0 deg)

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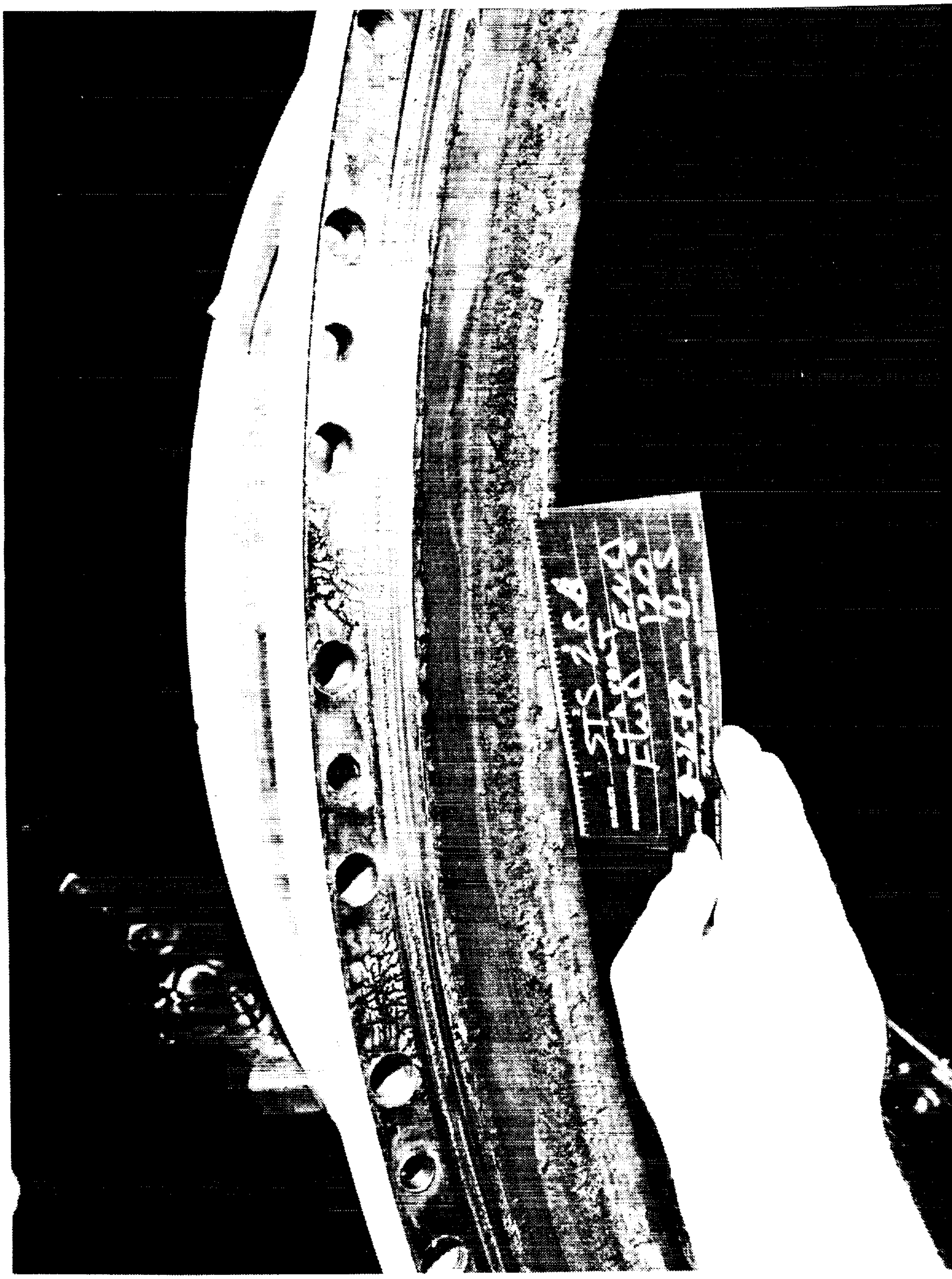

Figure 157 STS-28B Throat - Forward End (120 deg)

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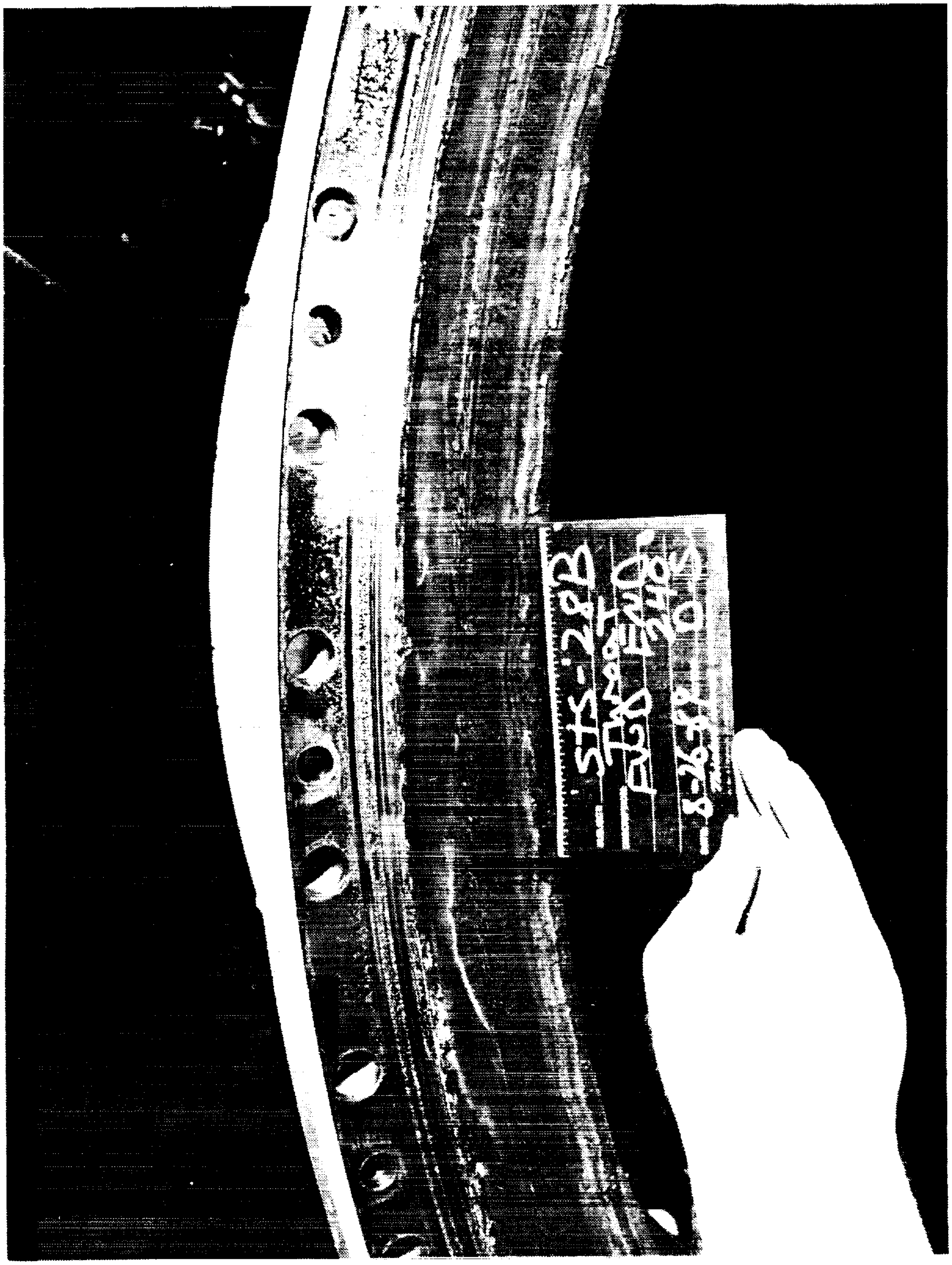

Figure 158 STS-28B Throat - Forward End (240 deg)

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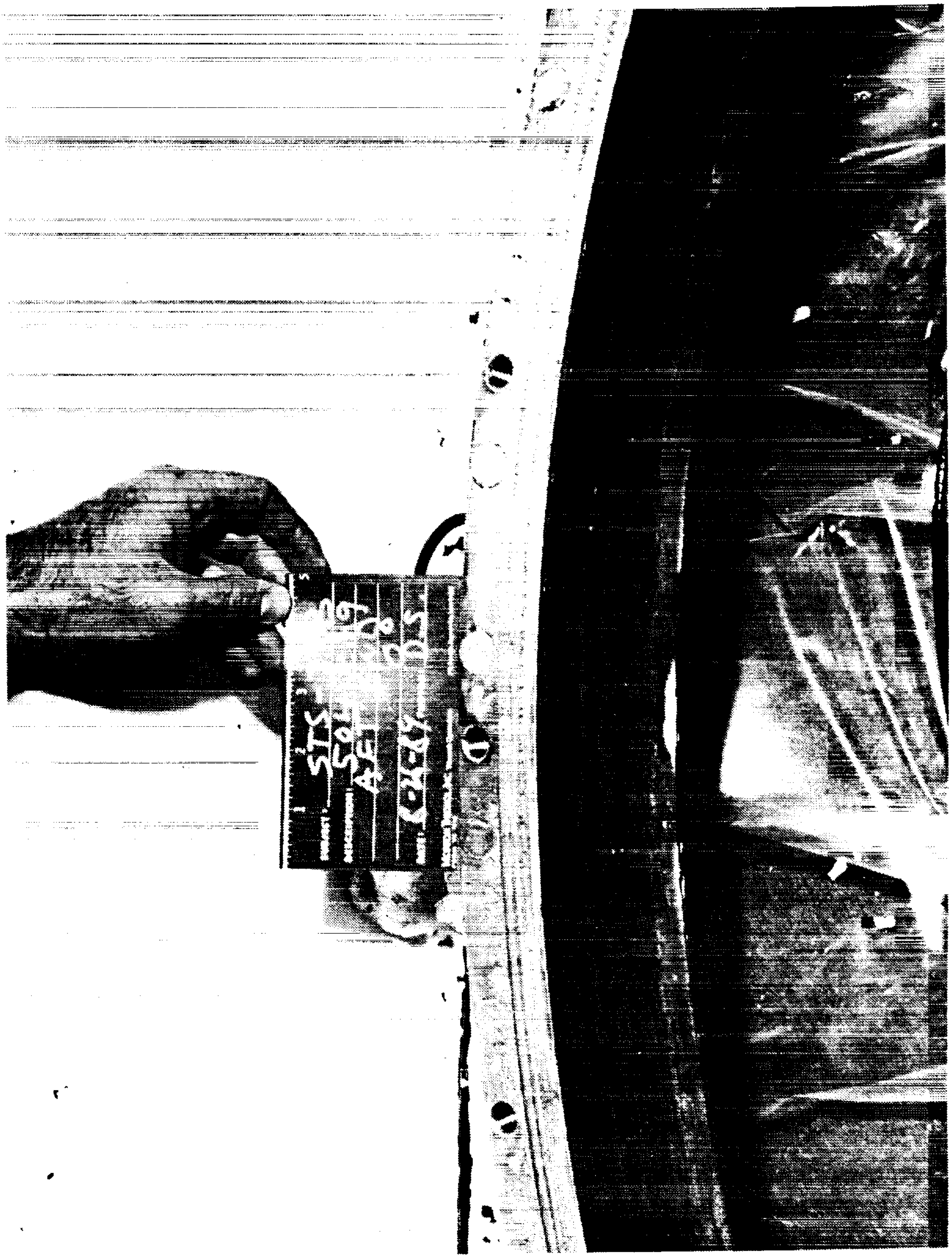

Figure 159 STS-28B Aft Inlet (-504) Ring - Aft End (0 deg)

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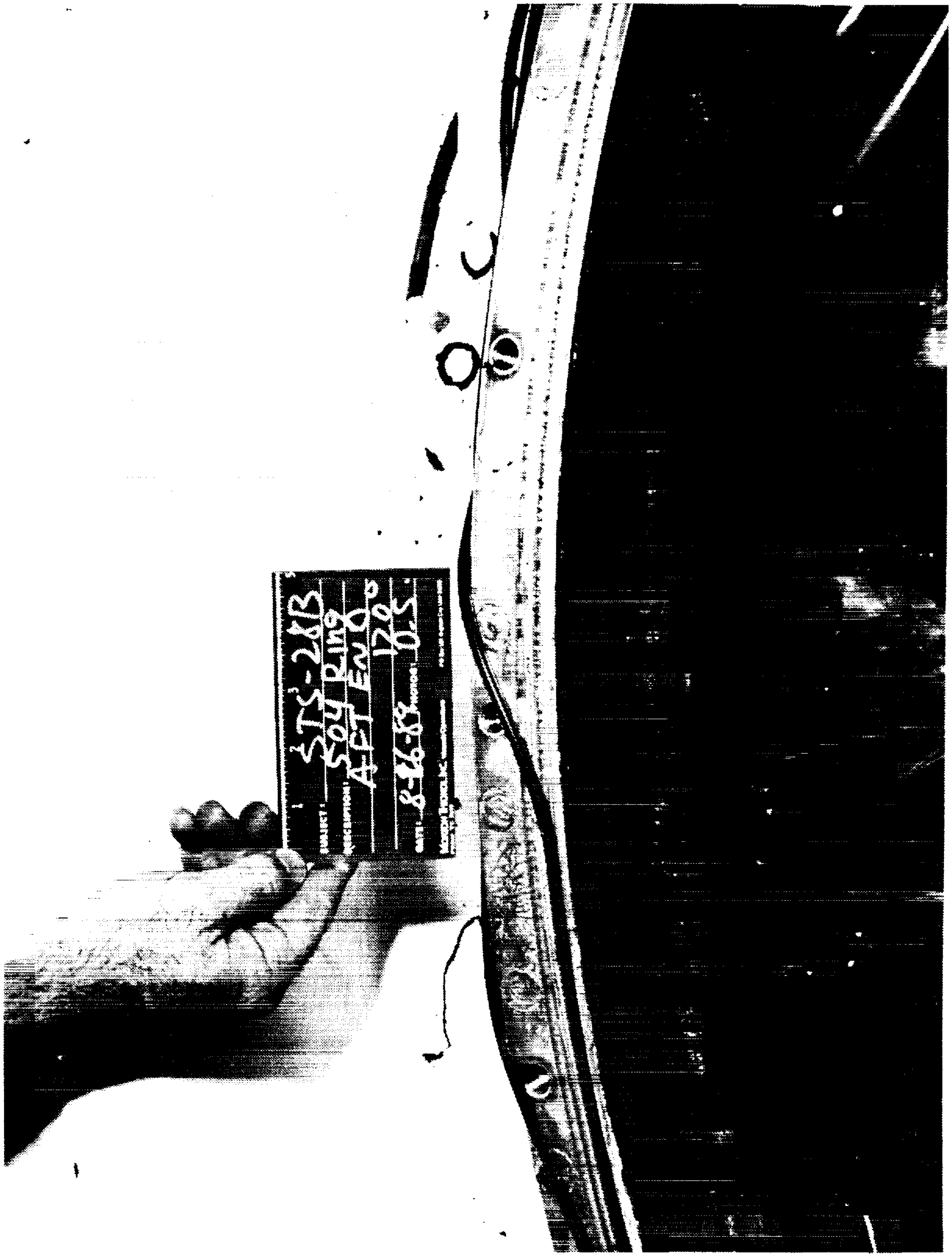

Figure 160 STS-28B Aft Inlet (-504) Ring - Aft End (120 deg)

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Figure 161 STS-28B Aft Inlet (-504) Ring - Aft End (240 deg)

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Figure 162 STS-28B Aft Inlet (-504) Ring - Aft End (203 deg)

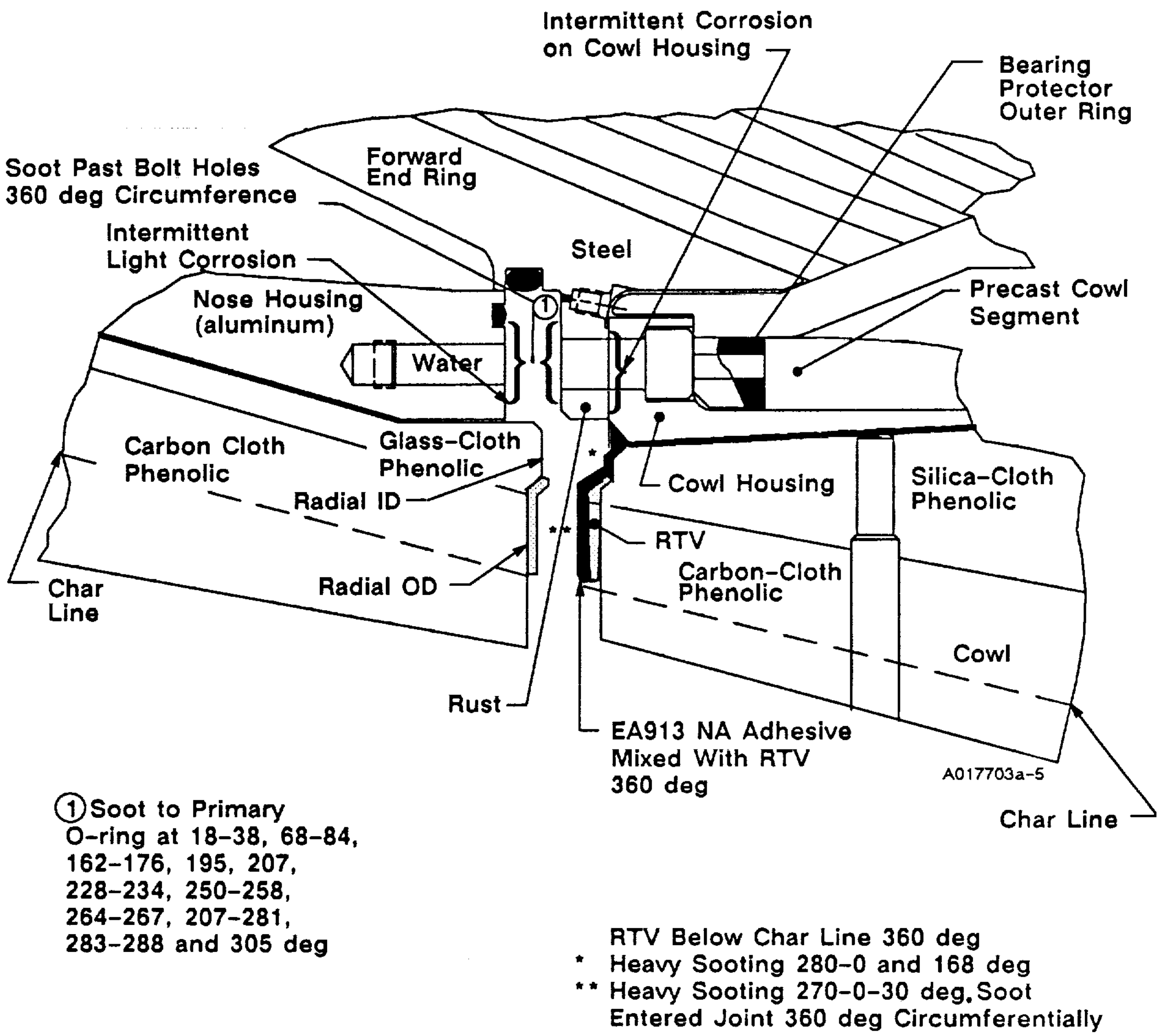

Figure 163 STS-28A Nose Inlet Housing/Flex Bearing Joint (Joint #2)

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Figure 164 STS-28B Cowl - Forward End (0 deg)

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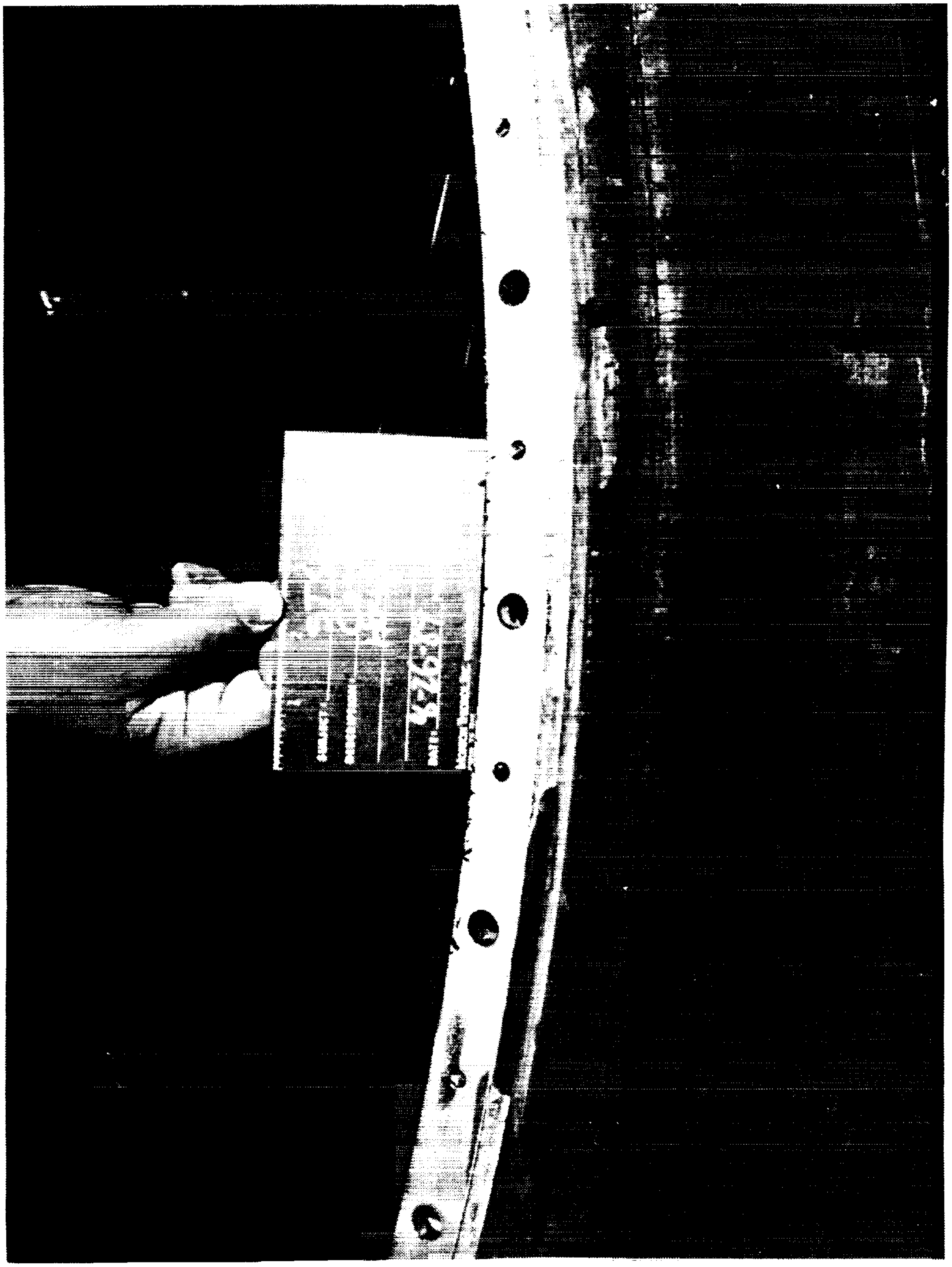

Figure 165 STS-28B Cowl - Forward End (120 deg)

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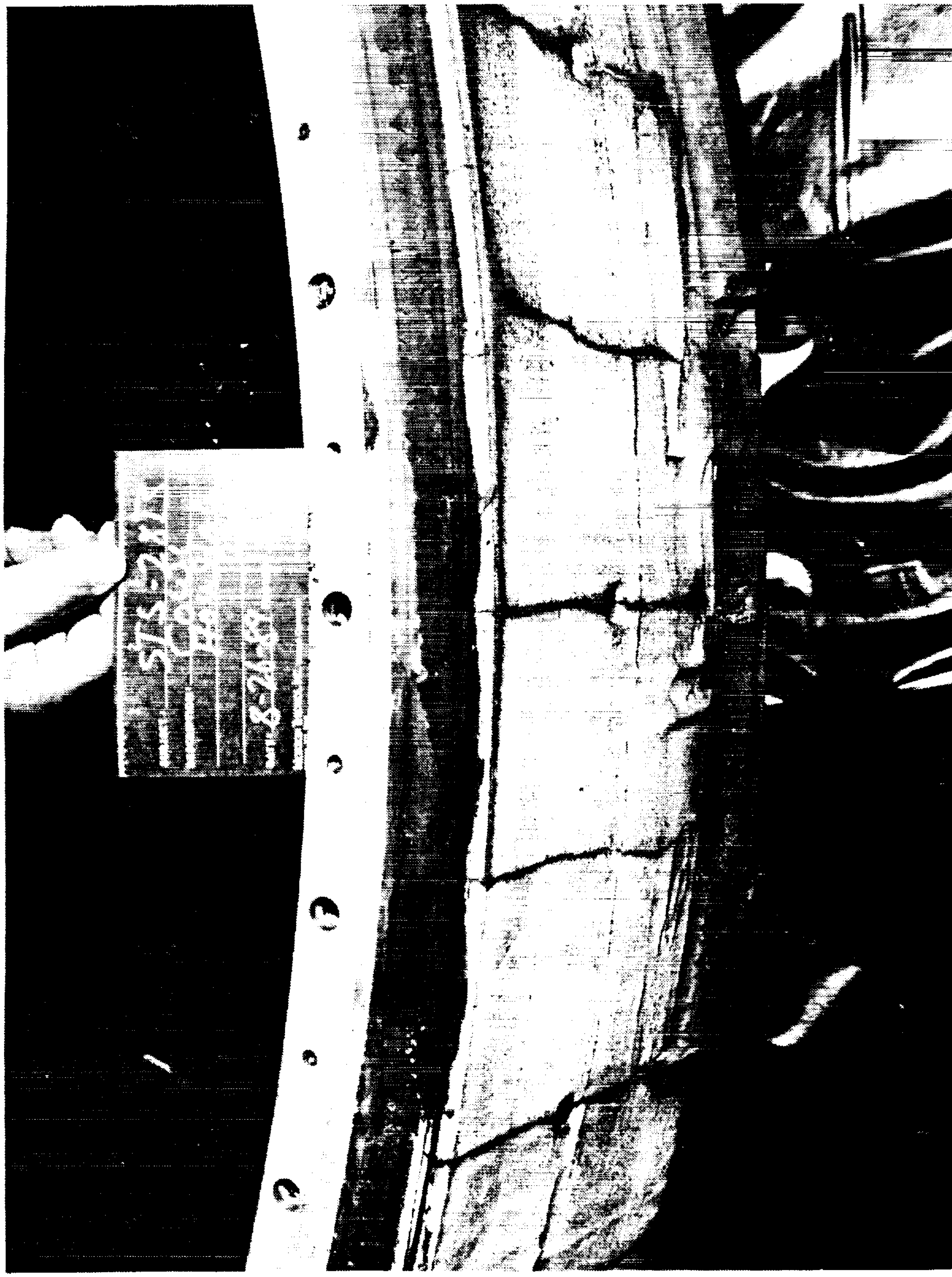

Figure 166 STS-28B Cowl - Forward End (240 deg)

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Figure 167 STS-28B Nose Cap - Aft End (0 deg)

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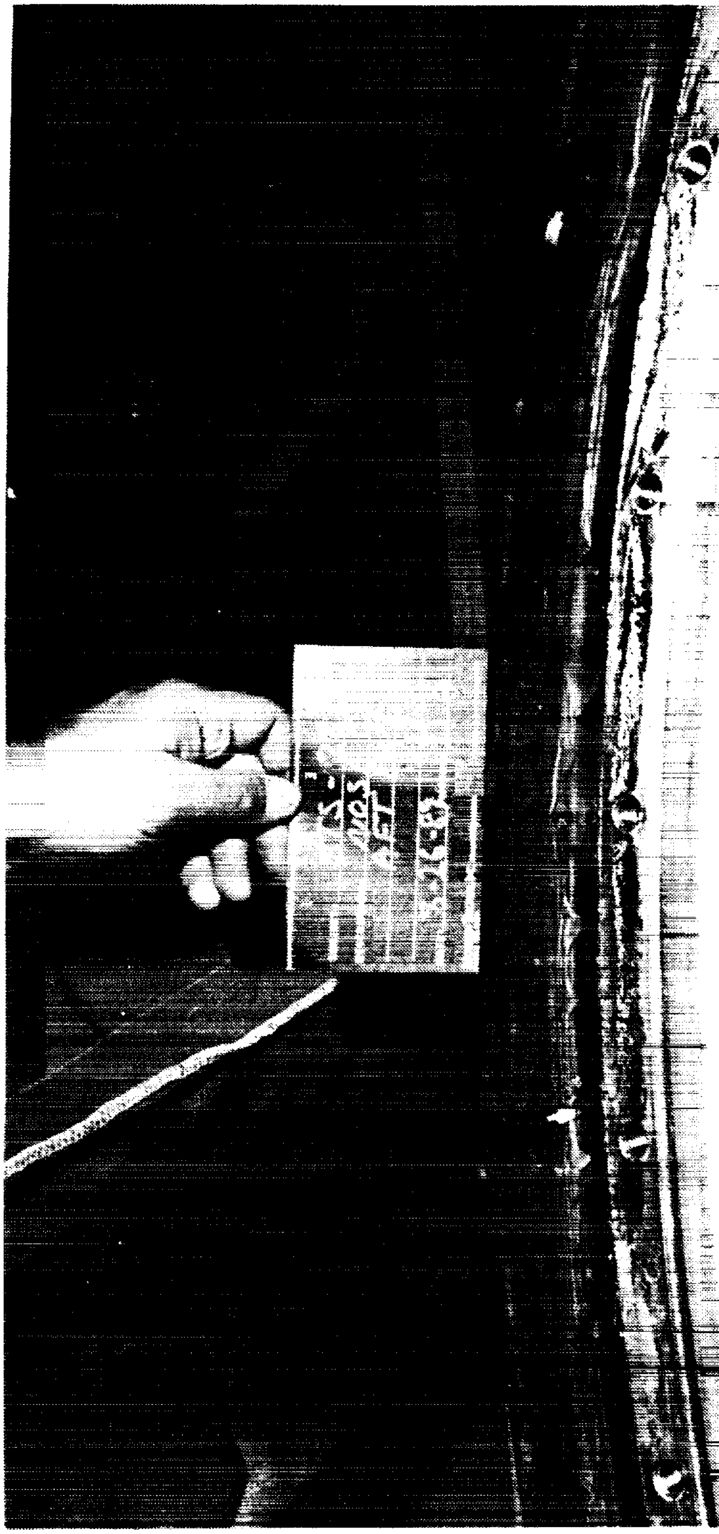

Figure 168 STS-28B Nose Cap - Aft End (120 deg)

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Figure 169 STS-28B Nose Cap - Aft End (240 deg)

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Figure 170 STS-28B Bearing Forward End Ring (0 deg)

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Figure 171 STS-28B Bearing Forward End Ring (120 deg)

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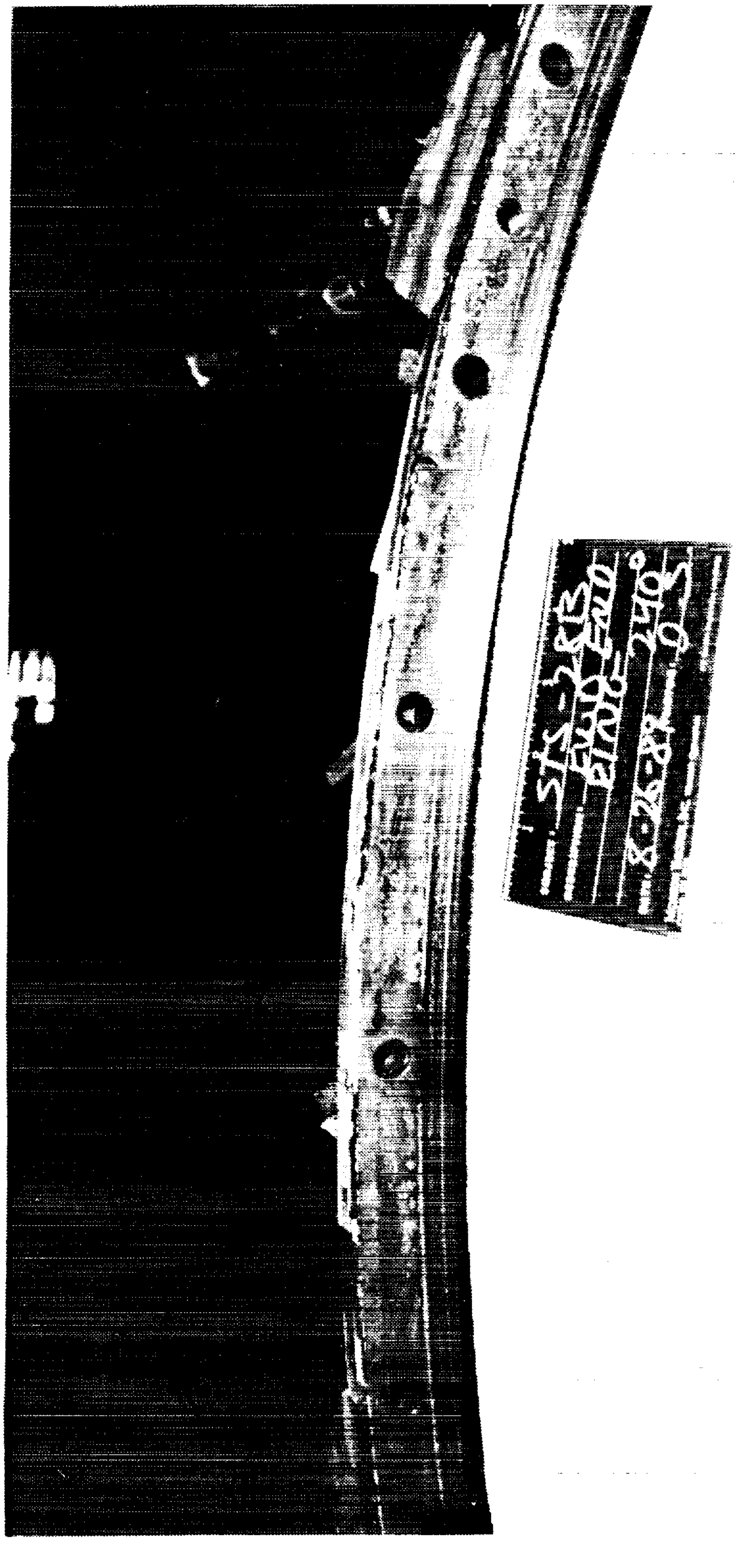

Figure 172 STS-28B Bearing Forward End Ring (240 deg)

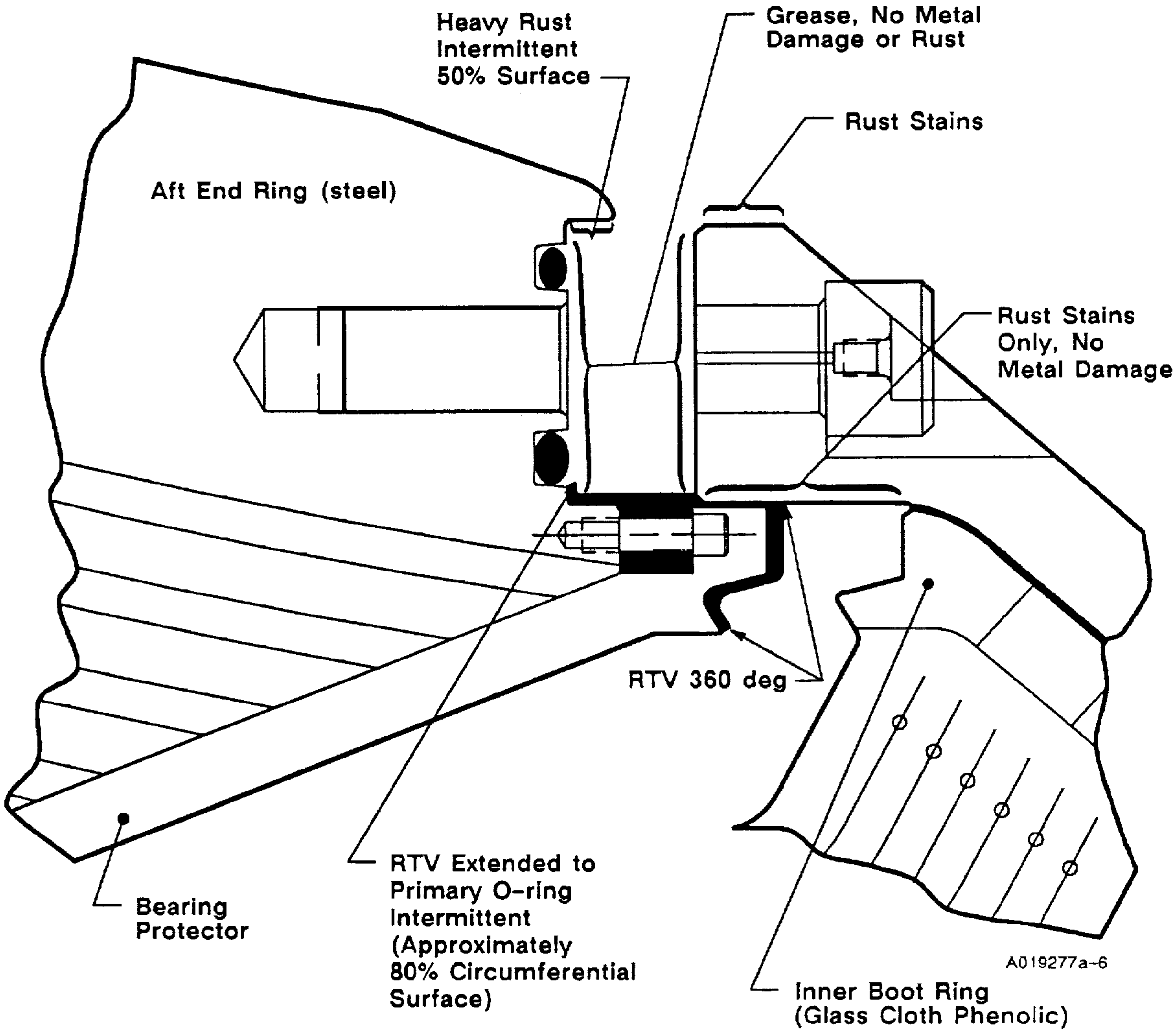

Figure 173 STS-28B—Flex Bearing/Fixed Housing Joint (Joint #5)

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Figure 174 STS-28B Bearing Aft End Ring (0 deg)

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Figure 175 STS-28B Bearing Aft End Ring (120 deg)

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Figure 176 STS-28B Bearing Aft End Ring (240 deg)

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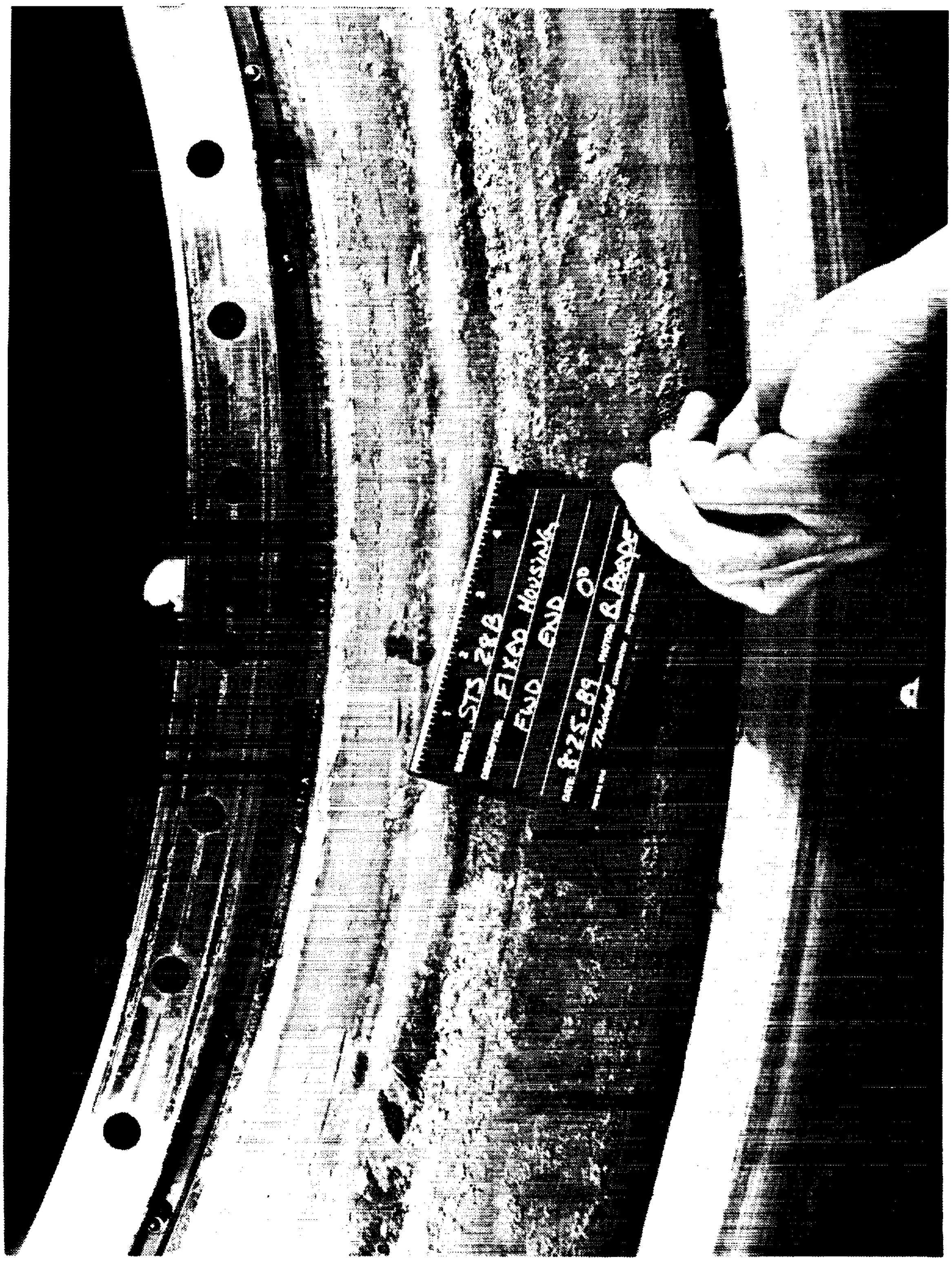

Figure 177 STS-28B Fixed Housing Forward End (0 deg)

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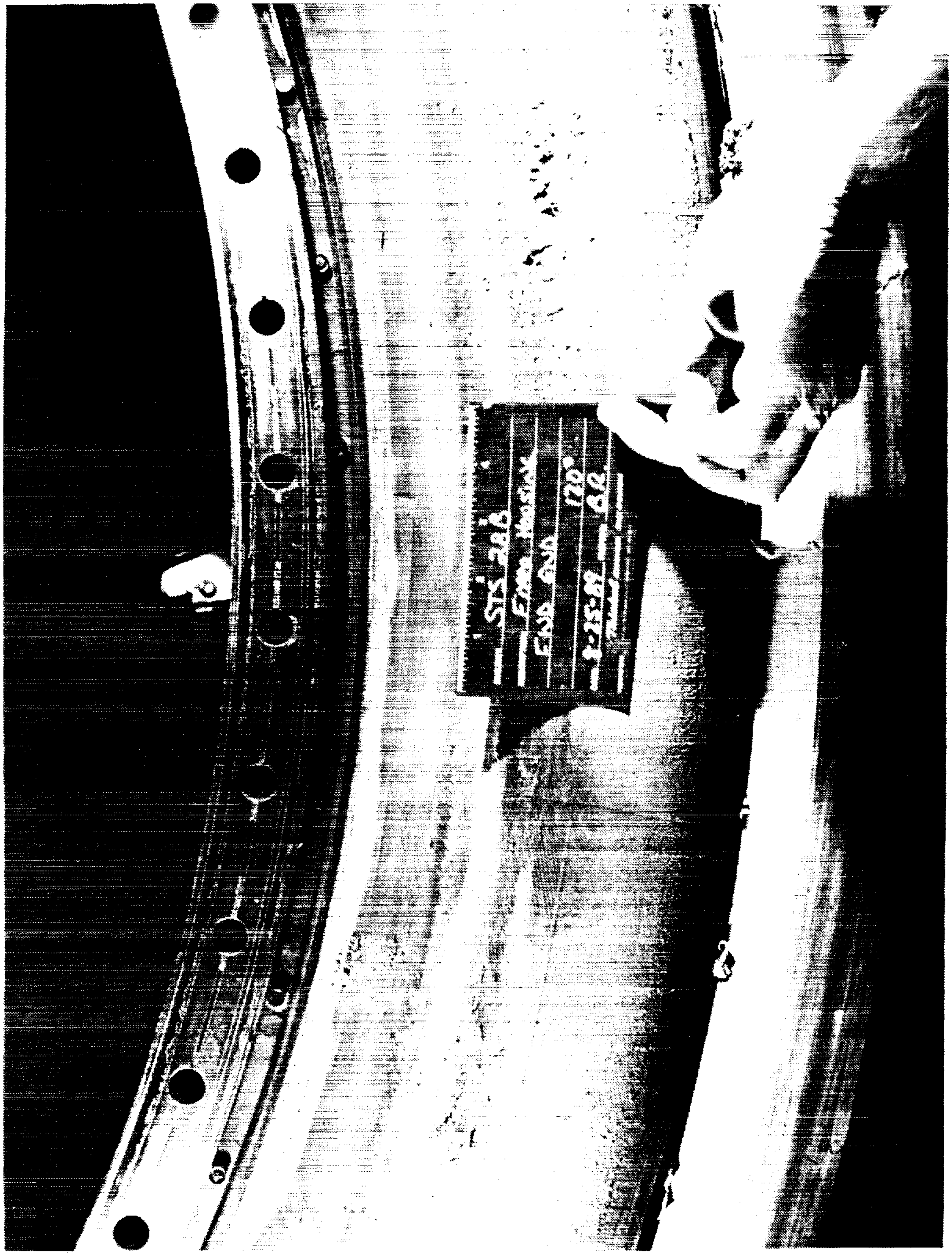

Figure 178 STS-28B Fixed Housing Forward End (120 deg)

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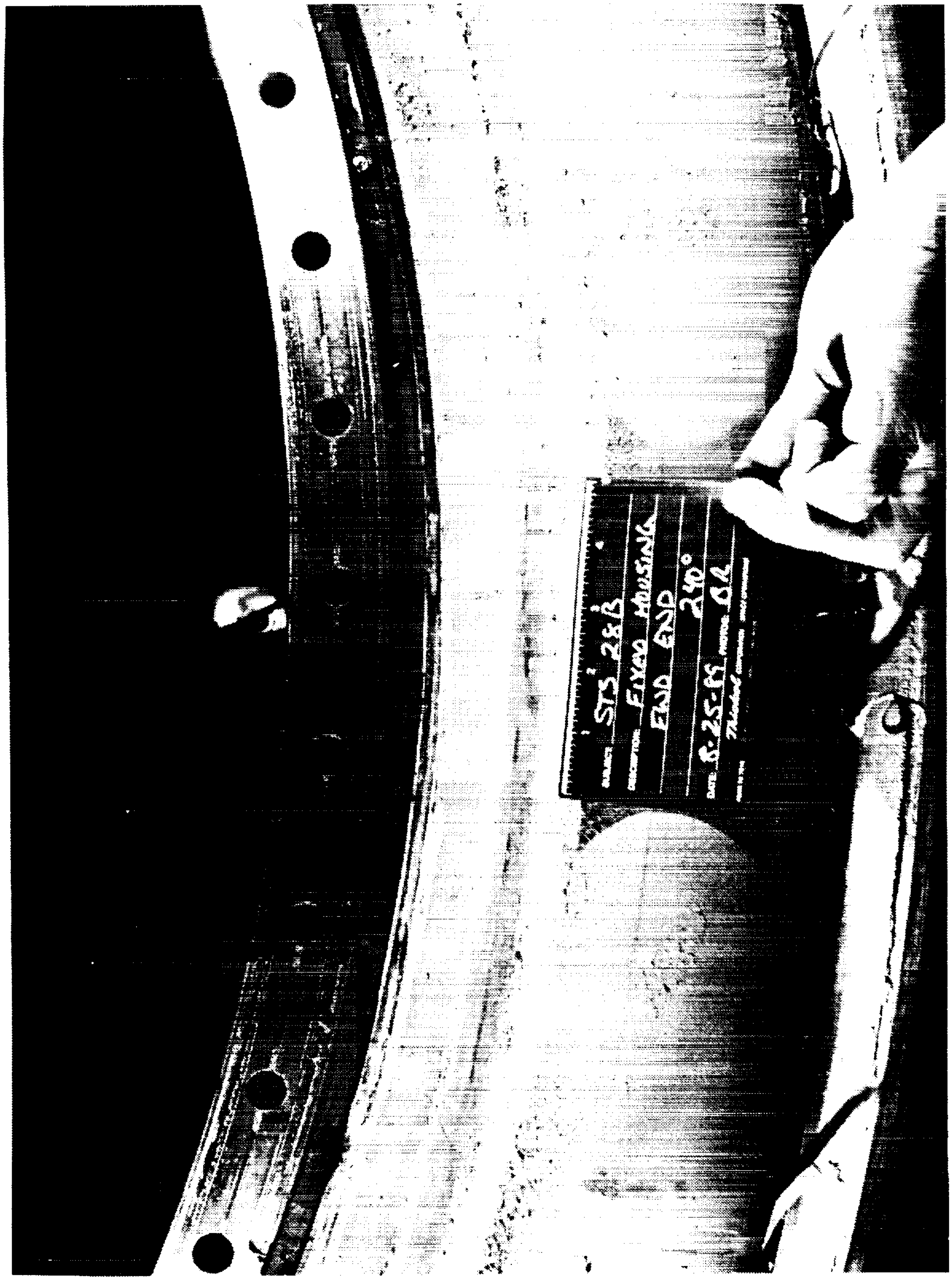

Figure 179 STS-28B Fixed Housing Forward End (240 deg)

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Appendix A

Nonconformance Discussion

DR 161110-01 Forward Exit Cone

Left-Hand Motor

P/N 5U52839-402, S/N 0000022
SMRB Criteria: 9, Waiver No.: RWW445

LDIs in Carbon Phenolic

Discrepancy

SB: No LDIs allowed in the carbon phenolic liner

Is: Two LDIs located in the carbon phenolic liner starting at the interface and running parallel to the ply direction. Size of both LDIs is 0.206 in. longitudinal length by 0.015 in. radial depth by 1.65 in. circumferential width; they are located 4.536 and 4.613 in. from forward end of 5U-configuration part at 342 deg

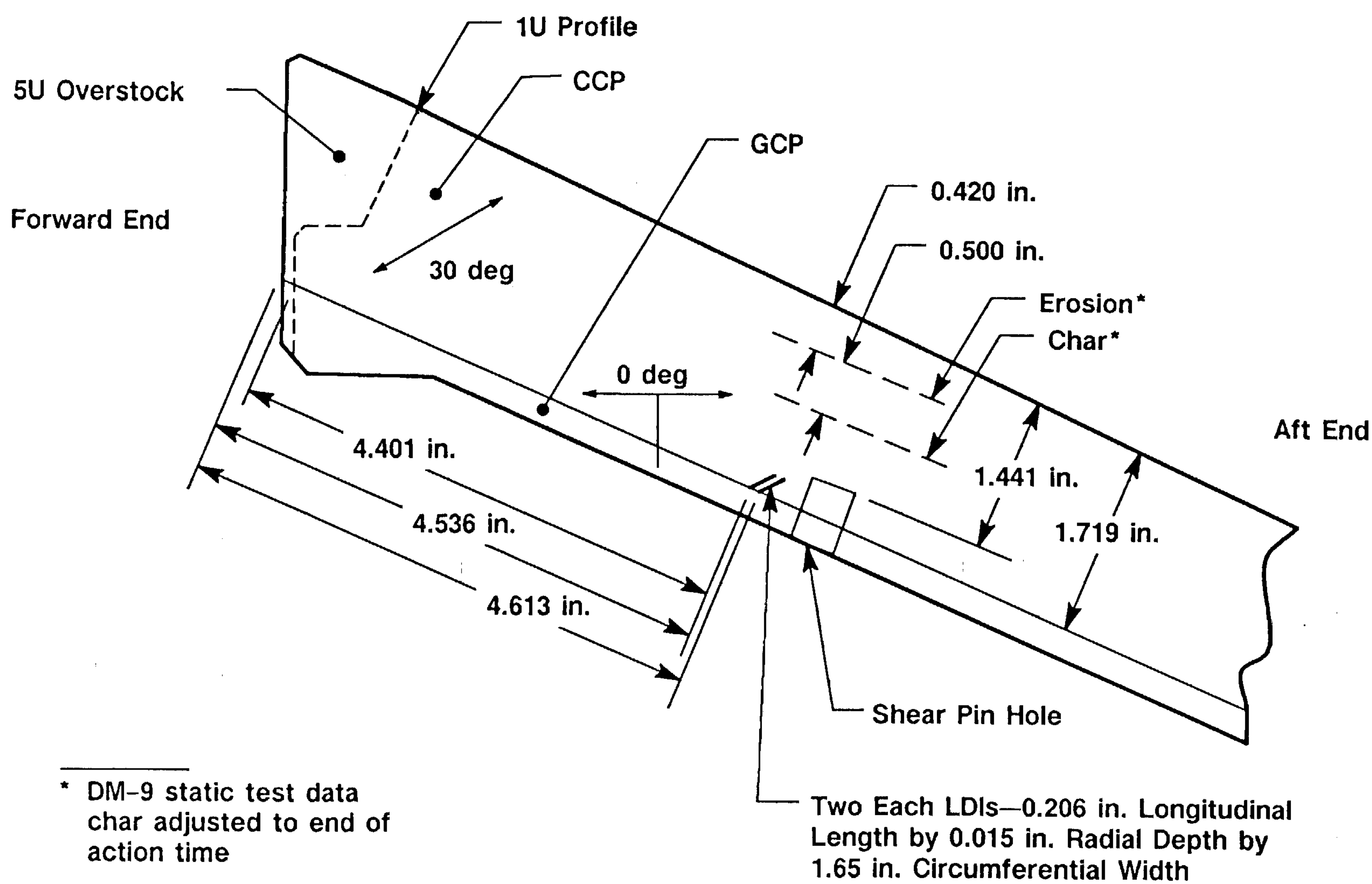
Disposition

Use as is

Nonconformance Discussion

DR 161110-01 Forward Exit Cone (Cont)

Left-Hand Motor



* DM-9 static test data char adjusted to end of action time

Nonconformance Discussion

DR 161110-01 Forward Exit Cone (Cont)

Left-Hand Motor

P/N 5U52839-402, S/N 0000022
SMRB Criteria: 9, Waiver No.: RWW445

LDIs in Carbon Phenolic

Justification

Indications lie below char and erosion lines at extreme OD of carbon phenolic liner

Alcohol wipe inspection of OD surface prior to glass overwrap was acceptable (no wetlines present)

Analysis shows minimum margin of safety (MMS) for interlaminar failure (delamination) is 8.33 (with a 1.4 factor of safety)

Ply separation modeled in the tensile region at worst time slice (110 sec); maximum tensile stress of 160 psi

Indications are shallower than the depth of the forward shear pin holes and located circumferentially between holes

SRM-17A successfully demonstrated worse condition (DR 110029). LDI was 0.100 in. closer to carbon ID surface

Waiver Status

Approved

360H005
B-20

Nonconformance Discussion

DR 169467-02, Nozzle Flex Bearing Assembly

Left-Hand Motor

P/N 1U52840-03, S/N 0000007R1
SMRB Criteria: 4 Waiver No.: None

Total Unbond Area, Pad

Discrepancy

SB: Pad total unbond area shall not exceed 20.0 in.^{2}

Is: Total unbond area of pad No. 4 is 22.6 in.^{2}; pad No. 7 is 22.8 in.^{2}; pad No. 10 is 102.6 in.^{2}

Note: Results of first stretch inspection in refurbishment cycle

Disposition

Use as is

Nonconformance Discussion

DR 169467–02, Nozzle Flex Bearing Assembly (Cont) — Left–Hand Motor

P/N 1U52840–03, S/N 0000007R1
SMRB Criteria: 4 Waiver No.: None

Total Unbond Area, Pad

Justification

- The total unbond area on pad No. 10 represents 1.62 percent of the total bond area in the pad
- The pad unbond areas did not change significantly from the inspection done prior to use in PV–1. Prior to the successful use in PV–1, pad No. 4 showed 12.3 in.^{2} (0.17 percent change); pad No. 7 showed 23.9 in.^{2} (–0.005 percent change); pad No. 10 showed 116.8 in.^{2} (0.22 percent change)
- This bearing has been successfully acceptance tested, which verified structural and sealing integrity
  - The acceptance testing included vectoring to over 7 deg under load and tensile leak testing
- The bearing will be in compression during motor operation
- Worst–case condition was this bearing when successfully used in PV–1 with a maximum pad unbond area of 116.8 in.^{2} (1.84 percent)
- Worse–case flight conditions were SRM–15B with 72.1 in.^{2} (1.20 percent) and STS–29B (360L003) with 75.8 in^2 (1.27 percent). Postflight observations conducted to date on STS–29B indicate acceptable performance

Nonconformance Discussion

DR 169467–03, Nozzle Flex Bearing Assembly

Left–Hand Motor

P/N 1U52840–03, S/N 0000007R1
SMRB Criteria: 4 Waiver No.: None

Total Unbond Area, Pad

Discrepancy

SB: Pad total unbond area shall not exceed 20.0 $in.^2$

Is: Total unbond area of pad No. 7 is 23.7 $in.^2$

Note: Result of second stretch inspection in refurbishment cycle

Disposition

Use as is

Nonconformance Discussion

DR 169467-03, Nozzle Flex Bearing Assembly (Cont)

Left-Hand Motor

P/N 1U52840-03, S/N 0000007R1
SMRB Criteria: 4 Waiver No.: None

Total Unbond Area, Pad

Justification

- The total unbond area on pad No. 7 represents only 0.38 percent of the total bond area in the pad
- Prior to the successful use of this bearing on PV-1, pad No. 7 had 23.9 $in.^2$ (-0.005 percent change) of unbond area; therefore, there was no significant change
- This bearing has been successfully acceptance tested, which verified structural and sealing integrity
  - The acceptance testing included vectoring to over 7 deg under load and tensile leak testing
- The bearing will be in compression during motor operation
- Worse-case flight conditions were SRM-15B with 72.1 $in.^2$ (1.20 percent) and STS-29B (360L003) with 75.8 in^2 (1.27 percent). Postflight observations conducted to date on STS-29B indicate acceptable performance

Nonconformance Discussion

PD 169735-01, Outer Boot Ring, First Wrap

Left-Hand Motor

P/N 5U75546-103, S/N 0000023
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

Discrepancy

SB: Hold at 220°±10°F for 60 to 90 min (autoclave stage cycle)

IS: Temperature was held at 220 ±10°F for 113 min, 23 min over maximum allowable

Disposition

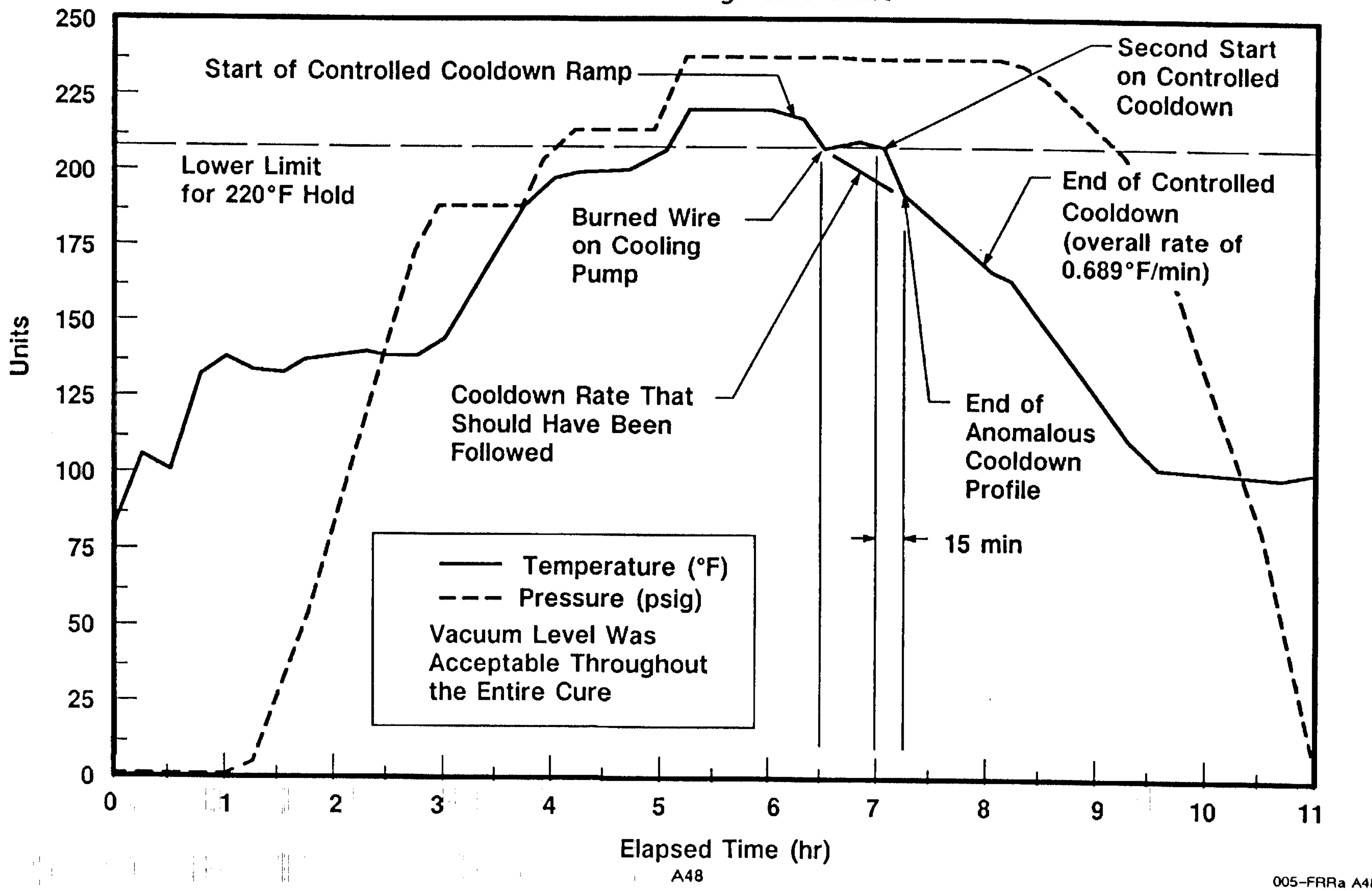
Acceptable departure

Nonconformance Discussion

PD 169735-01, 02, Outer Boot Ring, First Wrap (Cont)

Left-Hand Motor

Autoclave Stage Cure Chart



Nonconformance Discussion

PD 169735-01, Outer Boot Ring, First Wrap (Cont)

Left-Hand Motor

P/N 5U75546-103, S/N 0000023
SMRB Criteria: 10   Waiver No.: None

Cure Cycle Departure

Justification

Part jell and debulk are complete by end of normal 220°F hold

Additional time at this temperature will not impact part quality. The cure of the staged first wrap is completed during the second wrap full cure cycle

Carbon phenolic tag end properties are acceptable and fall within fired HPM outer boot ring data base

	Measured		Specification Limits	
	First Wrap	Second Wrap	Minimum	Maximum
Specific Gravity	1.45	1.46	1.40	1.55
Residual Volatiles (percent)	2.75	2.65	--	3.00
Resin Content (percent)	31.58	32.30	30.0	40.0
Compressive Strength (psi)	33,846	28,037	18,200	55,000

Nonconformance Discussion

PD 169735–01, Outer Boot Ring, First Wrap (Cont)

Left–Hand Motor

P/N 5U75546–103, S/N 0000023
SMRB Criteria: 10   Waiver No.: None

Cure Cycle Departure

Justification (Cont)

History of similar process departures

There is no history for this anomaly since redesign of the outer boot ring and incorporation of the two–stage cure. However, the HPM aft exit cone was cured in the same manner with the same materials and there is history of a similar cure departure

Aft exit cone liner (PD 115877–02, P/N 1U52188–02, S/N 0000025)

The carbon phenolic autoclave stage cure 220°±10°F hold was 139 min, 49 min over maximum allowable

Flown on SRM–19A with acceptable performance

Nonconformance Discussion

PD 169735–02, Outer Boot Ring, First Wrap

Left–Hand Motor

P/N 5U75546–103, S/N 0000023
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

<u>Discrepancy</u>

SB: Reduce temperature from 220°±10°F to 160°±10°F at an overall average rate not exceeding 0.5°F/min (autoclave stage cycle)

IS: Temperature was reduced at an overall average rate of 0.689°F/min

<u>Disposition</u>

Acceptable departure

<u>Justification</u>

Anomalous cooldown lasted 15 min, followed by a 1–hr cooldown at an acceptable rate of 0.5°F/min maximum

Alcohol wipe inspection acceptable, with no wetlines evidenced after each of three machining operations

100–percent radiographic (X–ray) inspection revealed no LDIs or other anomalies in the carbon billet

Nonconformance Discussion

DR 173080-01, -02 Aft Exit Cone Liner

Left-Hand Motor

P/N 5U76123-402, S/N 0000017
SMRB Criteria: 8, Waiver No.: None

LDIs in Glass-Cloth Phenolic (GCP)

Discrepancy

SB: LDIs within the GCP larger than 2.5-in. circumferential width, 1.9-in. longitudinal length, or 0.025-in. radial depth are unacceptable

Is: Numerous LDIs exceed one or more of the above dimensions (see sketch for size and general location)

Disposition

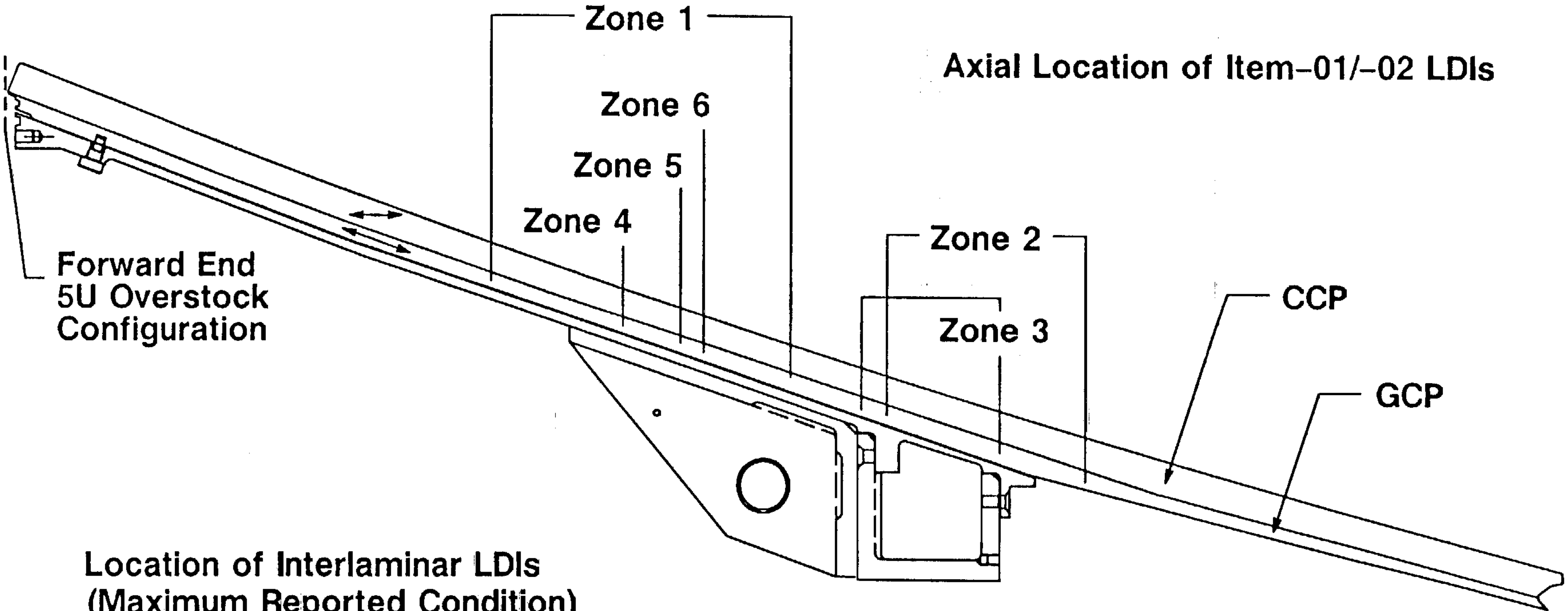
Use as is

Nonconformance Discussion

DR 173080-01,-02 Aft Exit Cone Liner (Cont)

Left-Hand Motor

Axial Location of Item-01/-02 LDIs



Location of Interlaminar LDIs
(Maximum Reported Condition)

Zone	Distance Aft of 5U Fwd End (in.)	Max Circum (in.)	Location (deg)	Max Long (in.)	Max Radial (in.)	No. of LDIs	Defect to Part OD (in.)
1	19.5-35.5	2.70	123	0.988	0.017	20	0.29
2	39.9-48.7	2.81	231	1.53	0.028	3	0.30
3	39.0-45.6	2.86	300	2.91	0.031	5	0.31
4	28.7	2.76	300	2.32	0.019	1	0.29
5	30.8	2.86	300	1.84	0.014	1	0.31
6	31.2	2.81	231	2.80	0.021	1	0.30

Nonconformance Discussion

DR 173080-01, -02, Aft Exit Cone Liner (Cont)

Left-Hand Motor

P/N 5U76123-402, S/N 0000017
SMRB Criteria: 8, Waiver No.: None

LDIs in GCP

Justification

- Structural analysis shows that LDIs will not propagate through glass phenolic during motor operation
  - LDIs are located in areas which remain in normal compression throughout motor operation; the interlaminar shear in the same areas is low (maximum of 200 psi)
- The design MMS for the aft exit cone GCP, including a 1.4 factor of safety, is 6.13 for interlaminar failure criteria (delamination) and 0.47 for in-plane failure criteria
  - None of the LDIs are located in either MMS region
- The MMS for the LDI area is 20.63 for interlaminar failure criteria (delamination) and 3.25 for in-plane failure criteria
- Tensile button and shear testing show no reduction in material strength due to ply-end LDIs (TWR-19228)
- Interlaminar and ply-end LDI conditions have been seen on the PV-1 and 360L001A and B aft exit cone GCP insulators. All of these cones showed nominal performance
- A change to the engineering acceptance criteria is being proposed. If approved, the revised criteria would accept the LDI conditions documented in this DR

Nonconformance Discussion

DR 173080-01, -02 Aft Exit Cone Liner

Left-Hand Motor

P/N 5U76123-402, S/N 0000017
SMRB Criteria: 8, Waiver No.: None

LDIs in Glass-Cloth Phenolic (GCP)

Discrepancy

SB: LDIs within the GCP larger than 2.5-in. circumferential width, 1.9-in. longitudinal length, or 0.025-in. radial depth are unacceptable

Is: Numerous LDIs exceed one or more of the above dimensions (see sketch for size and general location)

Disposition

Use as is

Nonconformance Discussion

DR 173099-01, Aft Exit Cone Assembly

Left-Hand Motor

P/N 1U76123-01, S/N 0000014
SMRB Criteria: 8, Waiver No.: None

LDIs in GCP

Discrepancy

SB: LDIs within the GCP larger than 2.5-in. circumferential width, 1.9-in. longitudinal length, or 0.025-in. radial depth are unacceptable

Is: Four LDIs exceed one or more of the above dimensions (see sketch for size and location); all classified as ply-end conditions (longitudinal length <0.200 in.)

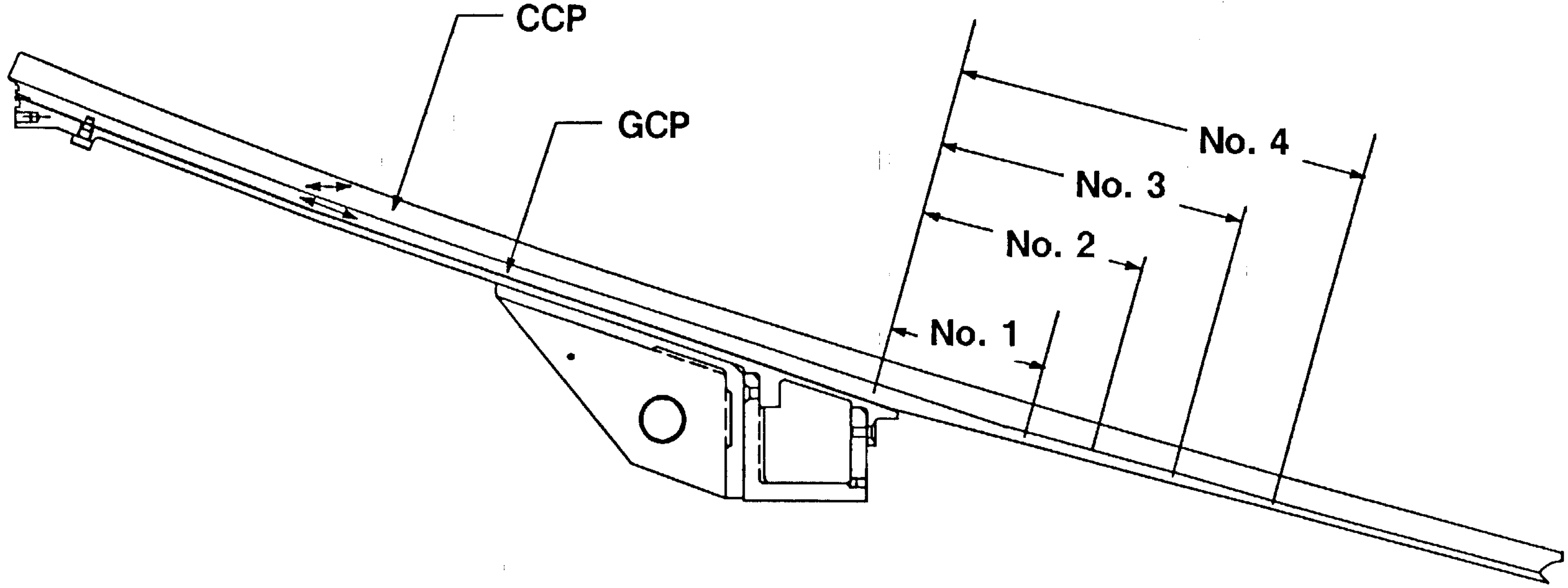
Disposition

Use as is

Nonconformance Discussion

DR 173099-01, Aft Exit Cone Assembly (Cont)

Left-Hand Motor



Location of Ply-End LDIs Within the GCP (maximum reported condition)

LDI No.	Distance Aft of Compliance Ring (in.)	Longitudinal Length (in.)	Radial Depth (in.)
1	8.19	0.092	0.031
2	11.57	0.029	0.027
3	15.90	0.048	0.027
4	21.36	0.068	0.027

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Nonconformance Discussion

DR 173099-01, Aft Exit Cone Assembly (Cont)

Left-Hand Motor

P/N 1U76123-01, S/N 0000014
SMRB Criteria: 8, Waiver No.: None

LDIs in GCP

Justification

Structural analysis shows that LDIs will not propagate through glass phenolic during motor operation

LDIs are located in areas which remain in normal compression throughout motor operation; the interlaminar shear in the same areas is very low (maximum of 30 psi)

The design MMS for the aft exit cone GCP, including a 1.4 factor of safety, is 6.13 for interlaminar failure criteria (delamination) and 0.47 for in-plane failure criteria

None of the LDIs are located in either MMS region

The MMS for the LDI areas is 97.6 for interlaminar failure criteria (delamination) and 0.82 for in-plane failure criteria (with 1.4 factor of safety)

Tensile button and shear testing show no reduction in material strength due to ply end LDIs (TWR-19228)

Ply-end LDI conditions have been seen on the PV-1 and 360L001A and B aft exit cone GCP insulators. All of these cones showed nominal performance

A change to the engineering acceptance criteria is being proposed. If approved, the revised criteria would accept the LDI conditions documented in this DR

Nonconformance Discussion

DR 173448-01 Fixed Housing Assembly

Left-Hand Motor

P/N 1U52862-01 (901), S/N 0000014
SMRB Criteria: 8 Waiver No.: None

Surface Blemish

Discrepancy

SB: Blemish less than 1.0 in. long, 0.125 in. wide, 0.030 in. deep is acceptable

IS: Blemish checks 1.900 in. long, 0.225 in. wide, 0.045 in. deep, located at 148 deg on carbon phenolic forward ID surface

Disposition

Repair—Remove blemish by machining

Justification

Radiographic (X-ray) inspection revealed no subsurface LDIs or cracks

The noted blemish has been completely removed by machining

After repair, alcohol wipe inspection showed no surface anomalies

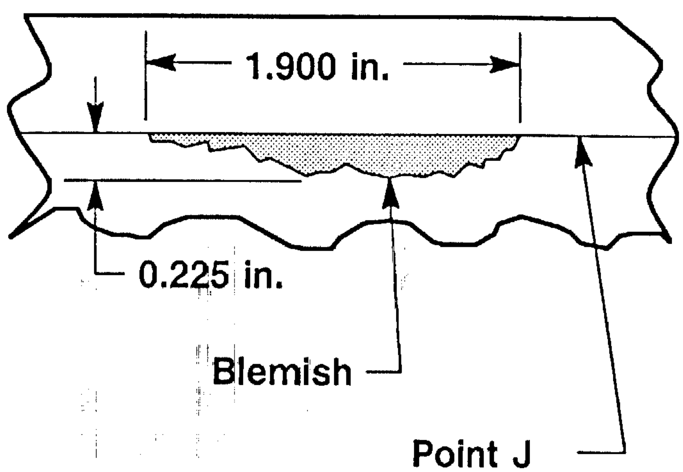
All sharp edges have been removed

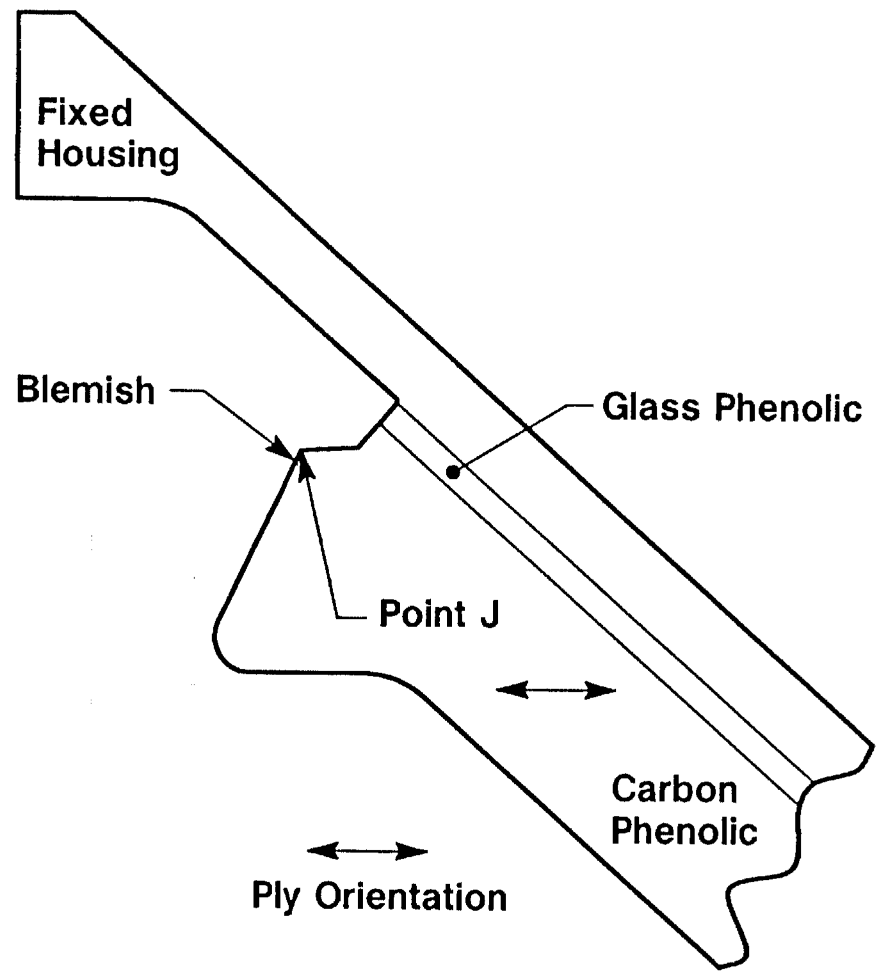
Note: Repair of this discrepancy resulted in the anomalous surface profile documented in Item -03 of this DR

Nonconformance Discussion

DR 173448-01 Fixed Housing Assembly

Left-Hand Motor





A87

005-FRRa A87

Nonconformance Discussion

DR 173448-02, Fixed Housing Assembly

Left-Hand Motor

P/N 1U52862-01 (901), S/N 0000014
SMRB Criteria: 8 Waiver No.: None

Wetline indications

Discrepancy

SB: No wetline indications allowed on machined surfaces of the carbon phenolic

Is: Numerous wetline indications evident on carbon phenolic forward ID. Maximum condition checks 13.5 in. circumferential length at 162 to 180 deg

Disposition

Repair—Remove wetline indications by machining

Justification

Radiographic (X-ray) inspection revealed no subsurface LDIs or cracks

The noted wetline indications have been completely removed by machining

After repair, alcohol wipe inspection showed no surface anomalies remain

All sharp edges have been removed

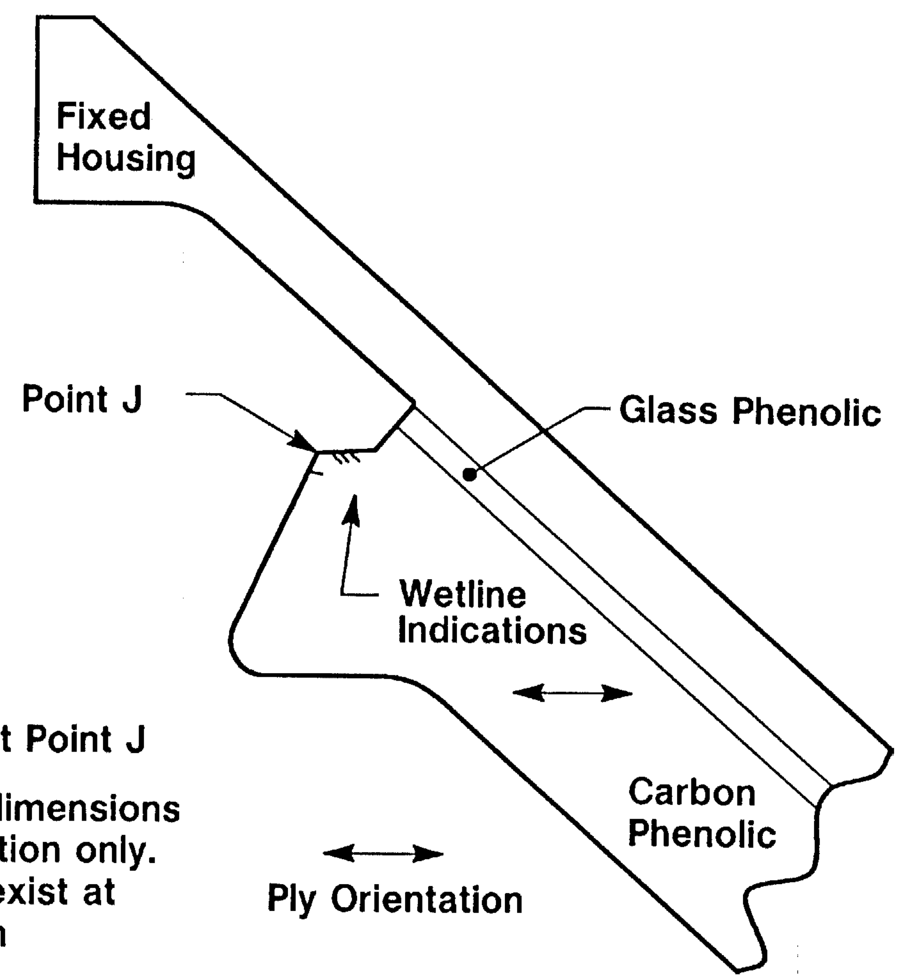
Note: Repair of these discrepancies resulted in the anomalous surface profile documented in Item -03 of this DR

Nonconformance Discussion

DR 173448-02, Fixed Housing Assembly (Cont)

Left-Hand Motor

Location (deg)	Circumferential Length (in.)	Radial Depth (in.)
141-150	3.000	Unknown
162-180	13.500	Unknown
200-205	2.300	Unknown
216-222	1.100	Unknown
265-272	4.200	Unknown



The wetline indications exist at Point J

Note: The above-mentioned dimensions are the maximum condition only. Other smaller wetlines exist at each noted deg location

360H005
B-34

Nonconformance Discussion

PD 169737-01, Outer Boot ring, First Wrap

Right-Hand Motor

P/N 5U75546-103, S/N 0000022
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

Discrepancy

SB: Hold at 220° ±10°F for 60 to 90 min (autoclave stage cycle)

Is: Temperature was held at 220°±10°F for 113 min, 23 min over maximum allowable

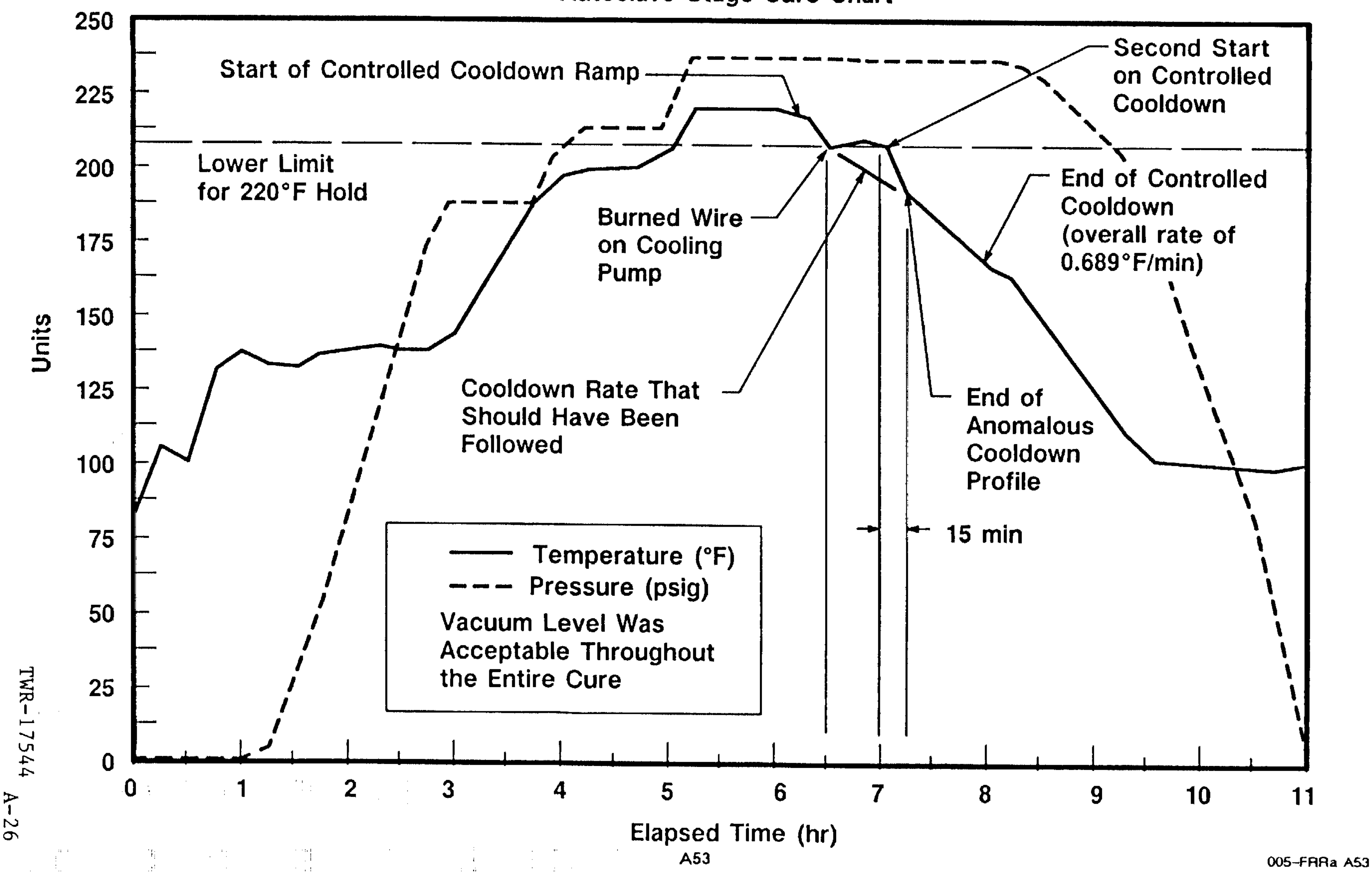
Disposition

Acceptable departure

Nonconformance Discussion

PD 169737-01,-02, Outer Boot Ring, First Wrap (Cont) — Right-Hand Motor

Autoclave Stage Cure Chart



Nonconformance Discussion

PD 169737–01, Outer Boot ring, First Wrap (Cont)

Right–Hand Motor

P/N 5U75546–103, S/N 0000022
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

Justification

Part jell and debulk are complete by end of normal 220°F hold

Additional time at temperature will not impact part quality. The cure of the staged first wrap is completed during the second wrap full cure cycle

Carbon phenolic tag end properties are acceptable and fall within fired HPM outer boot ring data base

	Measured		Specification Limits	
	First Wrap	Second Wrap	Minimum	Maximum
Specific Gravity	1.45	1.45	1.40	1.55
Residual Volatiles (percent)	2.34	2.18	--	3.00
Resin Content (percent)	31.47	31.33	30.0	40.0
Compressive Strength (psi)	33,626	32,454	18,200	55,000

Nonconformance Discussion

PD 169737-01, Outer Boot Ring, First Wrap (Cont)

Right-Hand Motor

P/N 5U75546-103, S/N 0000022
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

Justification (Cont)

History of similar process departures

There is no history for this anomaly since redesign of the outer boot ring and incorporation of the two stage cure. However, the HPM aft exit cone was cured in the same manner with the same materials and there is history of a similar cure departure

Aft exit cone liner (PD 115877-02, P/N 1U52188-02, S/N 0000025)

The carbon phenolic autoclave stage cure 220°±10°F hold was 139 min, 49 min over maximum allowable

Flown on SRM-19A with acceptable performance

Nonconformance Discussion

PD 169737-02, Outer Boot Ring, First Wrap

Right-Hand Motor

P/N 5U75546-103, S/N 0000022
SMRB Criteria: 10 Waiver No.: None

Cure Cycle Departure

Discrepancy

SB: Reduce temperature from 220°±10°F to 160°±10°F at an overall average rate not exceeding 0.5°F/min (autoclave stage cycle)

Is: Temperature was reduced at an overall average rate of 0.689°F/min

Disposition

Acceptable departure

Justification

Anomalous cooldown lasted 15 min, followed by a 1-hr cooldown at an acceptable rate of 0.5°F/min maximum

Alcohol wipe inspection acceptable, with no wetlines evidenced after each of three machining operations

100-percent radiographic (X-ray) inspection revealed no LDIs or other anomalies in the carbon billet

Nonconformance Discussion

DR 169782-03, Nozzle Flex Bearing Assembly

Right-Hand Motor

P/N 1U52840-03, S/N 0000005R1
SMRB Criteria: 4 Waiver No.: None

Pad Unbond

Discrepancy

SB: Maximum depth for a single unbond shall not exceed 3.2 inch

Is: Maximum unbond depth checks 3.4 in. on pad No. 3

Disposition

Use as is

Justification

Bearing performance, sealing, and structural integrity will not be affected

The maximum depth has not changed significantly since the previous refurbishment unbond inspection indicated a depth of 3.55 in. prior to the bearing's successful use on QM-7

The bearing has passed acceptance testing, which included being vectored to over 7 deg under load and tensile leak testing

The bearing is in compression during motor operation

The 1U51060-01, S/N 0000003R2 bearing successfully flew in SRM-1B, with a pad unbond depth of 3.21 in. (ref DR 50406-01)

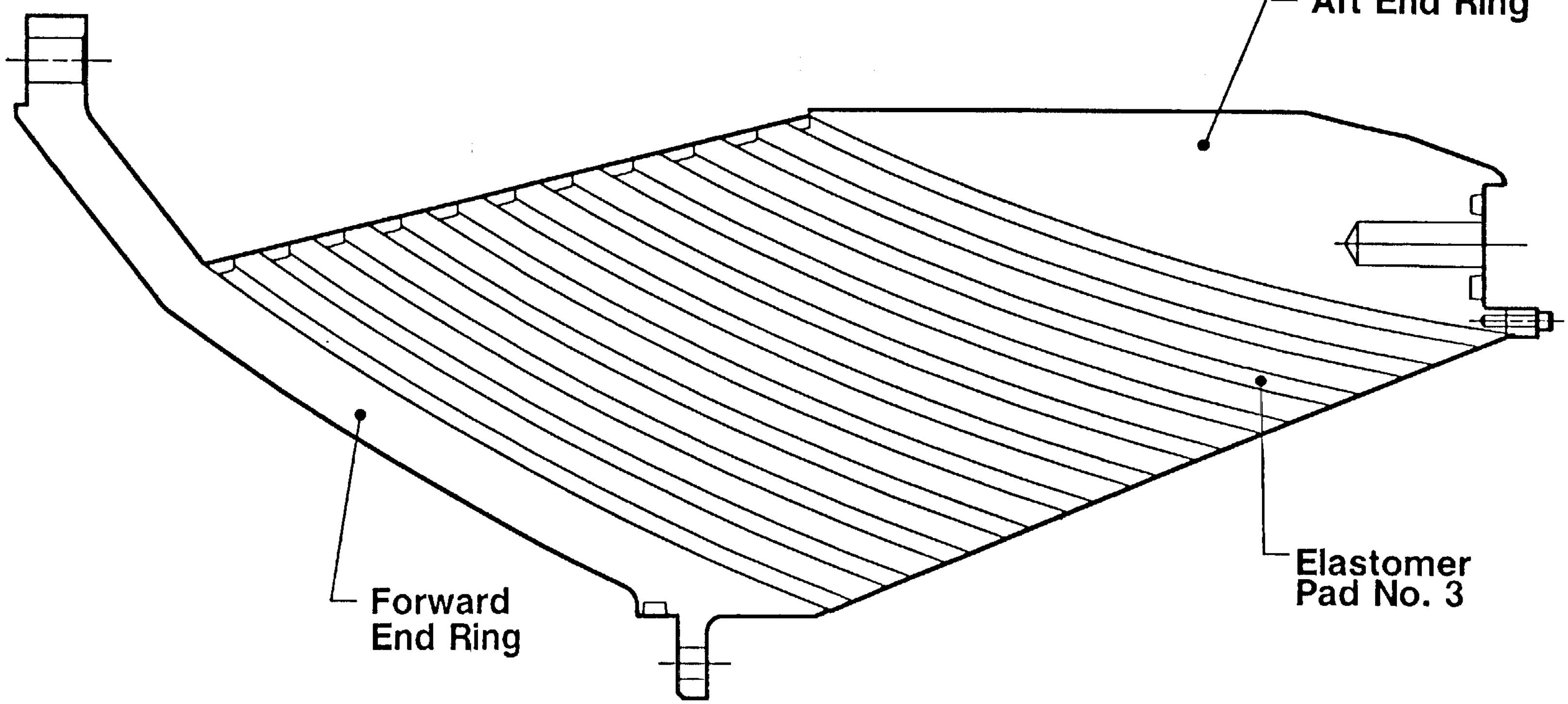
360H005
B-40

Nonconformance Discussion

DR 169782-03 Nozzle Flex Bearing Assembly (Cont)

Right-Hand Motor

Flex Bearing
Elastomer Pad Unbonds



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Nonconformance Discussion

DR 170806-01, Aft Exit Cone Assembly

Right-Hand Motor

P/N 1U76123-01, S/N 0000015
SMRB Criteria: 8, Waiver No.: None

LDIs in GCP

Discrepancy

SB: LDIs within the GCP larger than 2.5-in. circumferential width, 1.9-in. longitudinal length, or 0.025-in. radial depth are unacceptable

Is: Two areas contain LDIs which exceed one or more of the above dimensions. Maximum dimensions of any single LDI are 3.78 in. circumferential width or 0.110 in. longitudinal length or 0.040 in. radial depth

Area No. 1 is located 49.30 to 69.40 in. aft of part forward end

Area No. 2 is located 16.91 to 25.29 in. forward of part aft end

All classified as ply-end conditions (longitudinal length < 0.200 in.)

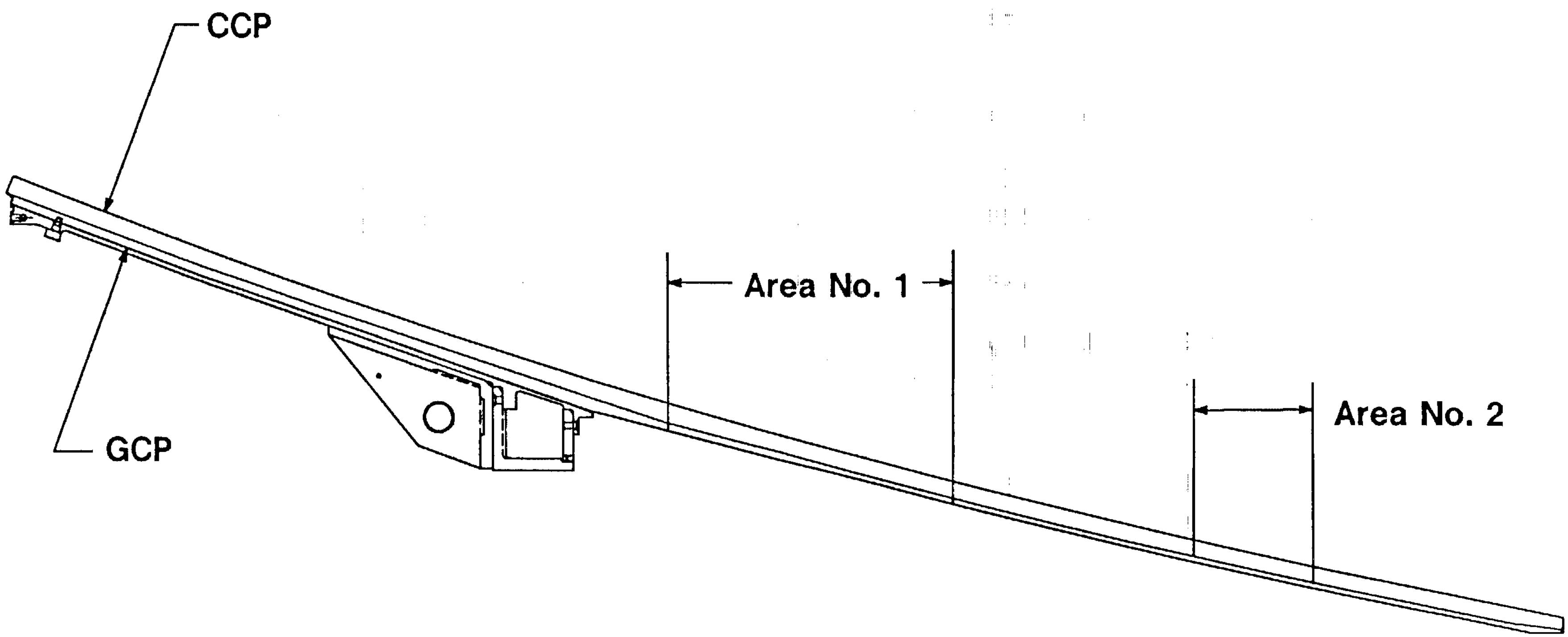
Disposition

Use as is

Nonconformance Discussion

DR 170806-01 Aft Exit Cone Assembly (Cont)

Right-Hand Motor



Nonconformance Discussion

DR 170806-01, Aft Exit Cone Assembly (Cont)

Right-Hand Motor

P/N 1U76123-402, S/N 0000017
SMRB Criteria: 8, Waiver No.: None

LDIs in GCP

Justification

- Structural analysis shows that LDIs will not propagate during motor operation
  - LDIs are located in areas which remain in normal compression throughout motor operation; the interlaminar shear in the same areas is very low (maximum of 100 psi)
- The design MMS for the aft exit cone GCP, including a 1.4 factor of safety, is 6.13 for interlaminar failure criteria (delamination) and 0.47 for in-plane failure criteria
  - None of the LDIs are located in either MMS region
- The MMS for the LDI areas is 49.0 for interlaminar failiure criteria (delamination) and 0.75 for in-plane failure criteria (with a 1.4 factor of safety)
- Tensile button and shear testing show no reduction in material strength due to ply-end LDIs (TWR-19228)
- Ply-end LDI conditions have been seen on PV-1 and 360L001A and B aft exit cone GCP insulators. All of these cones showed nominal performance
- A change to the engineering acceptance criteria is being proposed. If approved, the revised criteria would accept the LDI conditions documented on this DR

Nonconformance Discussion

DR 170806-02, Aft Exit Cone Assembly

Right-Hand Motor

P/N 1U76123-01, S/N 0000015
SMRB Criteria: 8, Waiver No.: None

High Density Indications in GCP

Discrepancy

SB: High density indication (HDI) with projected area less than 0.050 $in.^2$ is acceptable

Is: HDI with projected area of 0.0675 $in.^2$ (0.250 in. longitudinal by 0.270 in. circumferential) located in GCP, 36.14 in. forward of part aft end at 216 deg. HDI runs parallel to glass ply direction

Note: Six other HDIs exist in general area of noted HDI. All six have projected areas less than 0.050 $in.^2$

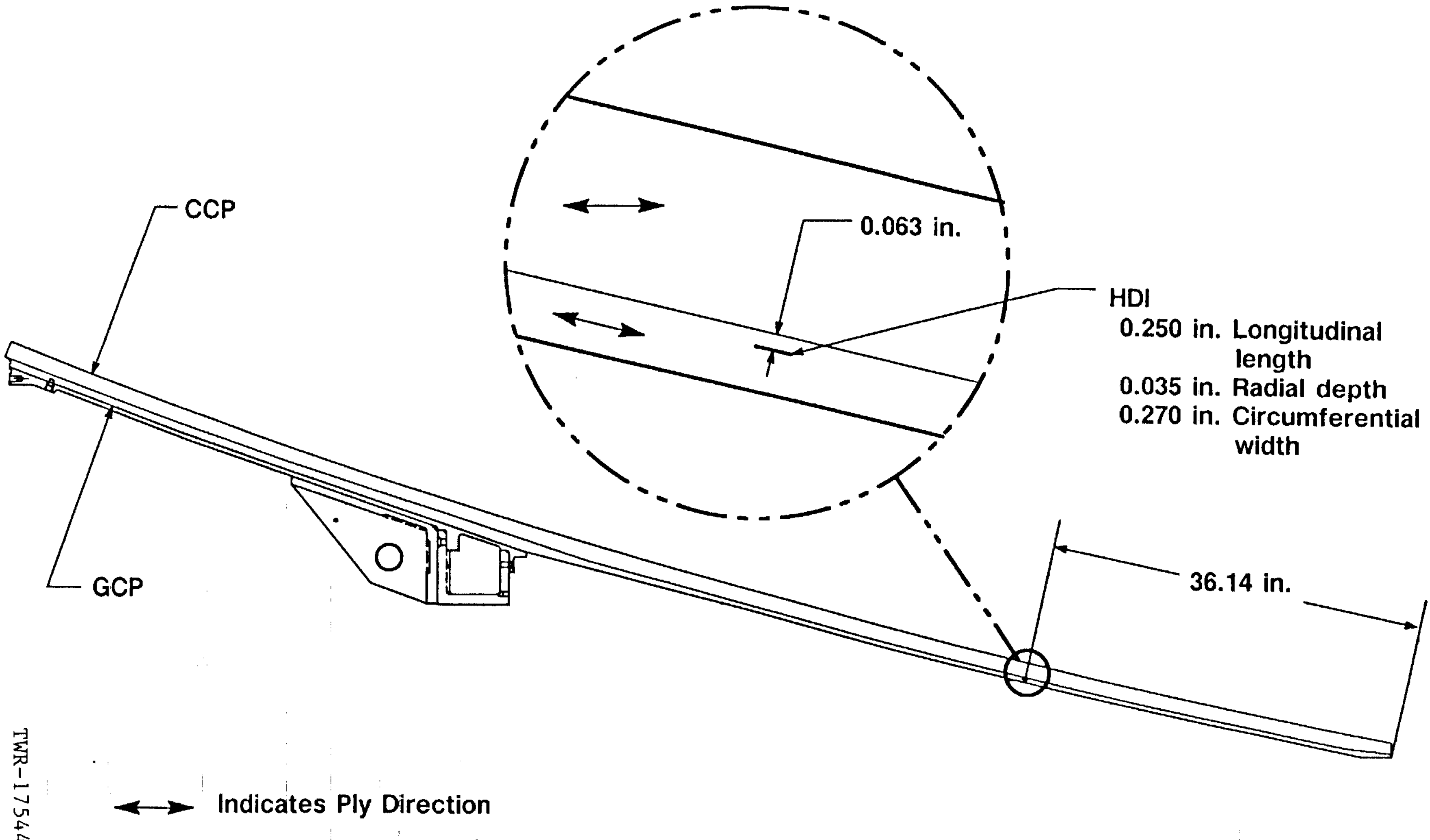
Disposition

Use as is

Nonconformance Discussion

DR 170806-02 Aft Exit Cone Assembly (Cont)

Right-Hand Motor



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Nonconformance Discussion

DR 170806–02, Aft Exit Cone Assembly (Cont)

Right–Hand Motor

P/N 1U76123–01, S/N 0000015
SMRB Criteria: 8, Waiver No.: None

HDIs in GCP

Justification

- Structural analysis shows that HDI will not propagate a delamination through the glass phenolic during motor operation
  - HDIs are located in areas which remain in normal compression during motor operation; the interlaminar shear stresses in those same areas are very low (maximum of 20 psi)
- The MMS in the region of the defects are 626 for interlaminar failure criteria (delamination) and 1.15 for in–plane failure criteria
  - Both minimum margins of safety include a 1.4 factor of safety
- A similar HDI was flown on the SRM–18A exit cone
  - Projected area of 0.066 $in.^2$ based on maximum dimensions of 0.487 in. longitudinal by 0.135 in. circumferential

Appendix B

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360H005A-03	3. INSPECTION LOCATION KSC X T-24/T-97	4. REFERENCE SQUAWK NUMBER 28-010	5. REFERENCE PR NUMBER PV6-136878
2. COMPONENT PROGRAM TEAM NOZZLE	H-7 A-2	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
FOREIGN RESIDUE ON AFT EXIT CONE LINER POLYSULFIDE GROOVE

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. JUSTIFICATION OF CLASSIFICATION
This condition represents a significant departure from the historical database. Corrective action is required but this problem has no impact on motor performance or program schedule.

11. PART NUMBER 1U76039-10	12. SERIAL NUMBER 0000001	13. PART DESCRIPTION AFT EXIT CONE ASSEMBLY

14. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
J. E. MILES / NOZZLE/FLEX BEARING PROJECT ENGINEERING / 08/13/89

15. RESPONSIBLE PROGRAM MANAGER (NAME / ORGANIZATION) E. L. DIEHL / NOZZLE PROGRAM MANAGEMENT	16. RESPONSIBLE POSTFIRE ENGINEER (NAME / ORGANIZATION) E. D. MOSES / POSTFIRE HARDWARE EVALUATION
17. RESPONSIBLE INTEGRATION ENGINEER (NAME / ORGANIZATION) H. D. HUPPI / SYSTEMS INTEGRATION ENGINEERING	18. RESPONSIBLE ACTIONEE (NAME / ORGANIZATION) R. J. GEORGE / NOZZLE/FLEX BEARING DESIGN ENGINEERIN

19. DESCRIPTION (ATTACH PFORS, FIGURES, PHOTOGRAPHS, ETC.)
Foreign residue from 265 to 271 degrees and a small pinhole at 268 degrees were found on the forward surface of the aftexit cone liner polysulfide groove.

20. HISTORY
This was a first-time RSRM occurrence.

21. CAUSE
See continuation sheet.

22. CORRECTIVE ACTION
The postflight team will continue to monitor future postflight aft exit cone joints. Recommend this PFAR be transferred to Thiokol LSS office at KSC for review of leak check and polysulfide repair procedures.

23. RESULTS
KSC Thiokol LSS office has conducted a review of the leak check and polysulfide repair procedures associated with this anomaly. Their attached response (ref. memorandum E690/RCH-90-A145, dated 5 March 1990) shows no apparent polysulfide repair procedures, leak check operations, or PR conditions during 360H005A processing that would result in the described foreign residue condition.

24. REPORT RESULTS TO RPRB? YES ___ NO X	26. APPROVAL THROUGH CORRECTIVE ACTION RPRB SECRETARY: /S/T. L. JOHNSON DATE: 09/06/89 SIE: /S/C. A. RUSSELL DATE: 09/07/89 PM: /S/E. L. DIEHL DATE: 09/07/89	27. CLOSURE RPRB SECRETARY: N/A DATE: N/A PM: /S/E. L. DIEHL DATE: 03/29/90
25. RPRB MEETING DATES ORIGINATION: 09/06/89 CLOSURE:		

REV. 2/1/90

21. CAUSE (continuation)

Analysis of the residue shows it to be silicon dioxide (silica). There were no blowpaths through the joint, indicating this did not occur during motor operation. This residue was in line with the leak check port at 268 degrees.

The pin hole was caused by removal of a small glass fiber during disassembly assessment. The pin hole was sectioned and observed to terminate approximately 0.3 inch deep within the polysulfide. The fiber is believed to have been introduced during polysulfide groove fill operations. At that time, nozzle processing was done in a non-contamination controlled building (M113). Thiokol polysulfide groove fill operations (as of 360L006) are now done in a contamination controlled facility. Airborne particulates such as small fibers cannot be introduced during processing in the clean room environment (M113A).

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360H005A-08	3. INSPECTION LOCATION KSC X T-24/T-97	4. REFERENCE SQUAWK NUMBER 28-032	5. REFERENCE PR NUMBER PV6-137178
2. COMPONENT PROGRAM TEAM NOZZLE	H-7 A-2	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
FOREIGN MATERIAL FOUND ON FIXED HOUSING

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. JUSTIFICATION OF CLASSIFICATION
This problem was previously identified on 360L002 and planning was updated to add methyl chloroform cleaning step.

11. PART NUMBER	12. SERIAL NUMBER	13. PART DESCRIPTION
1U52862-01	0000014	FIXED HOUSING ASSEMBLY

14. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING / 08/17/89

15. RESPONSIBLE PROGRAM MANAGER (NAME / ORGANIZATION) E. L. DIEHL / NOZZLE PROGRAM MANAGEMENT	16. RESPONSIBLE POSTFIRE ENGINEER (NAME / ORGANIZATION) E. D. MOSES / POSTFIRE HARDWARE EVALUATION
17. RESPONSIBLE INTEGRATION ENGINEER (NAME / ORGANIZATION) C. A. RUSSELL / SYSTEMS INTEGRATION ENGINEERING	18. RESPONSIBLE ACTIONEE (NAME / ORGANIZATION) R. J. GEORGE / NOZZLE/FLEX BEARING DESIGN ENGINEERIN

19. DESCRIPTION (ATTACH PFORS, FIGURES, PHOTOGRAPHS, ETC.)
White, sticky material was found on the fixed housing forward of the primary o-ring at the EA-913 interface.

20. HISTORY

21. CAUSE
There was insufficient cleaning of the adhesive tape residue left subsequent to finalization of the liner bonding operations.

22. CORRECTIVE ACTION
Update planning to adequately clean the surface after liner bonding operations.

23. RESULTS
Manufacturing Engineering has changed the planning (see OCR PAR No. 159122) to include cleaning of the surface. This is contained in Log No. 4871M, Op. 065, Step 525. They will also discuss this situation with the operations personnel. This procedure will be effective for Flight 10B and subsequent.

24. REPORT RESULTS TO RPRB? YES ___ NO X	26. APPROVAL THROUGH CORRECTIVE ACTION RPRB SECRETARY: /S/T. L. JOHNSON DATE: 09/06/89 SIE: /S/C. A. RUSSELL DATE: 09/07/89 PM: /S/E. L. DIEHL DATE: 09/07/89	27. CLOSURE RPRB SECRETARY: /S/S. T. MUNSON DATE: 02/15/90 PM: /S/E. L. DIEHL DATE: 02/13/90
25. RPRB MEETING DATES ORIGINATION: 09/06/89 CLOSURE:		

REV. 2/1/90

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360H005B-13	3. INSPECTION LOCATION KSC ___ T-24/T-97 ___	4. REFERENCE SQUAWK NUMBER N/A	5. REFERENCE PR NUMBER N/A
2. COMPONENT PROGRAM TEAM NOZZLE	H-7 X A-2 ___	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
FOREIGN MATERIAL FOUND IN NOZZLE JOINT #3

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. JUSTIFICATION OF CLASSIFICATION
This condition represents a significant departure from the historical database.

11. PART NUMBER N/A	12. SERIAL NUMBER N/A	13. PART DESCRIPTION NOSE INLET-TO-THROAT JOINT

14. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
L. E. WILKES / NOZZLE/FLEX BEARING DESIGN ENGINEERING / N/A

15. RESPONSIBLE PROGRAM MANAGER (NAME / ORGANIZATION) E. L. DIEHL / NOZZLE PROGRAM MANAGEMENT	16. RESPONSIBLE POSTFIRE ENGINEER (NAME / ORGANIZATION) /
17. RESPONSIBLE INTEGRATION ENGINEER (NAME / ORGANIZATION) C. A. RUSSELL / SYSTEMS INTEGRATION ENGINEERING	18. RESPONSIBLE ACTIONEE (NAME / ORGANIZATION) R. J. GEORGE / NOZZLE/FLEX BEARING DESIGN ENGINEERIN

19. DESCRIPTION (ATTACH PFORS, FIGURES, PHOTOGRAPHS, ETC.)
During Clearfield nozzle disassembly, black powdery residue was found in Joint #3.

20. HISTORY

21. CAUSE
The black powdery residue was found to be a mix of charred RTV (DC90-006) and carbon cloth phenolic mixed with seawater. During splashdown, this residue was forced into the joint. Reference memo 2463-FY90-M041.

22. CORRECTIVE ACTION
No corrective action is required. Close PFAR.

23. RESULTS
N/A

24. REPORT RESULTS TO RPRB? YES X NO ___	26. APPROVAL THROUGH CORRECTIVE ACTION RPRB SECRETARY: /S/T. L. JOHNSON DATE: 09/07/89 SIE: /S/C. A. RUSSELL DATE: 09/07/89 PM: /S/E. L. DIEHL DATE: 09/07/89	27. CLOSURE RPRB SECRETARY: /S/S. T. MUNSON DATE: 02/15/90 PM: /S/E. L. DIEHL DATE: 02/13/90
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